DOUBLE FEATURE: STATE-OF-THE-ART MOVIE THEATERS

HIGH TECHNOLOGY

JUNE 1987 THE MAGAZINE FOR TECHNOLOGY MANAGEMENT PRICE $3.00

CELL CULTURE

LIVING CHEMICAL FACTORIES YIELD VALUABLE DRUGS

REVOLUTION IN TOYLAND

BELL LABS SPINOFFS

Yves Fouron of Bio-Response

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We work hard to earn these stripes.

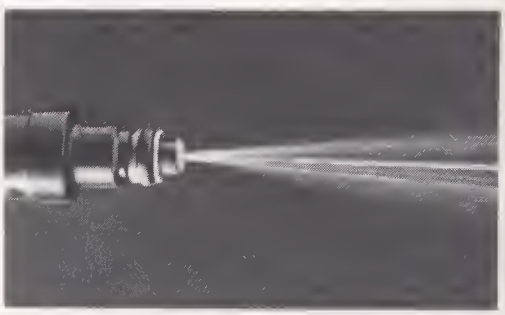
When nearly 700 senior executives were polled* on the companies that they associated with high quality, they named more than 200 different American, Asian and European firms. But one company was named more than twice as often as any other: IBM.

Still, a reputation for quality isn't something you can rest on. That's why we keep working hard to earn our stripes.

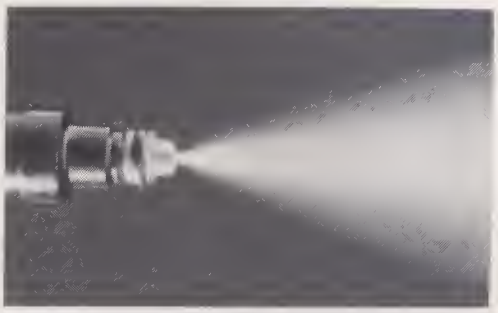
*Commissioned by The American Society for Quality Control. For a free copy write ASQC, 310 West Wisconsin Ave., Milwaukee, WI 53203.

Drive your engine clean.

Mobil Super Unleaded can unclog dirty fuel injectors and give your car a new injection of power.



Clogged fuel injector.



Unclogged fuel injector.

One of the biggest problems facing today's high-tech engines is clogged fuel injectors.

Deposits can form in port injectors—cutting the flow of fuel and making your engine slow, sluggish, unresponsive.

But you don't have to make expensive trips to a repair shop to clean the fuel injectors in your car.

You can fix the problem yourself—simply by driving with Mobil Super Unleaded.

Advanced Detergent Formula

All grades of Mobil unleaded detergent gasoline keep fuel injectors clean.

But Mobil Super Unleaded has an advanced detergent formula that can actually unclog dirty fuel injectors—as you drive—giving your car a new injection of power.

Leading Edge Technology

While other oil companies are only starting to talk about fuel injector problems, Mobil, the detergent gasoline leader for over 20 years, has been recognized by auto manufacturers, car dealers and consumers as having the gasoline that solves the fuel injector problem: Mobil Super Unleaded.

High Octane With A Plus

Mobil Super Unleaded has high octane to give your car the power and performance you want.

So fill up with Mobil Super Unleaded. And drive your engine clean.

Mobil
Super Unleaded
High octane with a plus

Circle No. 53 on Reader Service Card.

A Hughes Aircraft Company Value Engineering Change Proposal (VECP) significantly improved the design of a power control unit used on the M1 Abrams Tank and Bradley Fighting Vehicle and led to a savings of $9.09 million for the U.S. Army over the life of the two programs. Hughes improved the power control unit's reliability and producibility by calling for changes in three circuit board modules. The result was fewer components, an increase in electrical efficiency, and a reduction in the number of spares needed. Ongoing participation in value engineering programs resulted in the Army Material Command awarding Hughes the Outstanding Achievement in Value Engineering Award for 1985.

Spectacular nighttime rescue aided by Hughes' Nightsun® searchlight, the most powerful searchlight ever developed for lightweight helicopters. When an aerial gondola cable linking Sentosa Island with Singapore was damaged by a towed oil rig, panicky passengers dangled high over the water in complete darkness. A police helicopter illuminated the scene nearly as brightly as the sun with the Nightsun searchlight, while a second helicopter rescued the passengers. The searchlight is built by Spectrolab, a Hughes subsidiary. It provides 30 million candlepower, as compared with the maximum 900,000 of ordinary searchlights.

A new computer "assistant" that uses artificial intelligence will help U.S. Army technicians repair the primary weapon system on the AH-1 Cobra helicopter in the field more quickly and thoroughly than ever—and at less cost. The unit will be used for the M65 airborne TOW missile system and can be applied to virtually any complex weapon system including electronic, optical, mechanical, and hydraulic equipment. It will employ human logic to guide a maintenance technician automatically through a sequence of diagnostic steps and will recommend to the technician which tests should be conducted. The system will help reduce maintenance costs by being accurate and fast. Hughes, which builds the Tube-launched, Optically tracked, Wire-guided (TOW) missile and M65 system, is developing this new diagnostic unit for the U.S. Army Aviation Applied Technology Directorate.

Brazil has expanded its telecommunications service now that the new Brazilsat 2 satellite has gone into operation. The spacecraft joins Brazilsat 1 in uniting the wilderness along the Amazon Basin with the more populated regions in the south. The two satellites carry telephone, TV, and data services. Spar Aerospace Ltd. of Canada built the Brazilsats under license from Hughes for EMBRATEL, Brazil's state-owned telecommunications agency. Hughes supplied antenna reflectors, solar cell arrays, propulsion systems and other electronic components and subsystems.

Hughes is seeking experienced engineers and scientists to further develop advanced spacecraft systems and components for communications satellites. Openings are in the fields of: software, computers, and data processing systems; electrical components; microwave/RF communication systems development; on-board spacecraft electronics and control systems; satellite design, integration, propulsion, and electrical power system development; spacecraft manufacturing, systems test and evaluation; GaAs applications R&D. Send your resume to Dan Frownfelter, Hughes Space & Communications Group, Dept. S2, S4/A300, P.O. Box 92919, Los Angeles, CA 90009. EOE. U.S. citizenship required.

For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

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JUNE 1987

HIGH TECHNOLOGY

VOL. 7, NO. 6

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OPINION

THE INFORMATION EDGE FOR THE INFORMATION AGE

HIGH TECHNOLOGY has always been a magazine of new directions. Now we are taking a new direction ourselves. Look at the tiny type at the bottom right of this page, and you will see a name you have not seen before: Infotechnology Publishing Corporation. Effective with this issue, Infotechnology is the owner and publisher of HIGH TECHNOLOGY—and has made a long-term commitment to continue bringing you the strengths of the magazine, while making the information provided even more useful to your business and personal life.

You will see that commitment building in the months to come, as we make this magazine the leading publication that gives businesspeople the edge to profit from high technology.

We take every part of that mission statement seriously:

LEADING PUBLICATION. No one else explores the technology that is transforming our lives and businesses as deeply as we do. Look, for example, at "Harvesting the cell," p. 36—not only to find out the latest developments in this area of biotechnology, but also to see how many companies, and which ones, are involved in the research.

BUSINESSPEOPLE. You are our target audience. If you need to know about upcoming technology to decide whether to purchase it—or to stay ahead of your competitors if *they* purchase it . . . if you need to understand the trends that will transform the way you do business in the months and years to come . . . if you are starting or growing a business, and are looking to technology to help you find the right market niche . . . then you need HIGH TECHNOLOGY—because only HIGH TECHNOLOGY can give you the advance information you need to make your company more competitive.

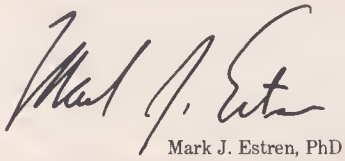
THE EDGE. By now, you probably know what we are driving at: we give you the edge on your competition by showing what the technological trends will be, long before you can learn of them through other sources. Everyone calls this the Information Age, but we believe there is, in a sense, *too much* information: an explosion of such magnitude that it is enormously hard to separate what is important from what is not. By highlighting what is important to your business or investment life (see, for instance, "Investing the high tech way," p. 68), HIGH TECHNOLOGY gives you the information edge in our Information Age.

PROFIT. We believe in it. So do you, or you wouldn't be in business. Our aim is to show you how the latest technological developments in all fields can be turned to the advantage of your bottom line.

Our bottom line is that we intend to make HIGH TECHNOLOGY a success by focusing it on you, our business-oriented readers, while continuing to present the in-depth information on technology that you have come to expect.

Oh, yes—we also intend to have some fun with what technology does to our lives (see "Revolution in Toyland," p. 38).

Watch in coming months as we introduce exciting new ways to help you understand and profit from the ever-increasing pace of technological change. Whatever the needs of your business, HIGH TECHNOLOGY will be an indispensable tool.



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This CAD image of Quincy Market in Boston was created by Skok Systems of Cambridge, Mass., for demonstration at A/E/C Systems '87.

COURTESY SKOK SYSTEMS, INC

A/E/C Systems: A really big show

As the controversy wages as to who has the largest graphics show ("Graphics conference on videotape," Updates, Dec. 1986, p. 6, and "A graphic overstatement," Letters, March 1987, p. 7), a sleeping giant lurks.

Although focused on the vertical market surrounding graphic communications (the architecture, engineering, and construction industries), A/E/C Systems '87 is larger than SIGGRAPH '86 and the National Computer Graphics Association's (NCGA) Computer Graphics '87. Computer Graphics '87 had a roster of 180 companies, covering 110,000 square feet, whereas A/E/C Systems '87 will have more than 400 companies exhibiting in 130,000 square feet.

NCGA and SIGGRAPH produce very fine events and are commended for setting the computer graphics awareness trends that allow conferences in practical graphics applications such as A/E/C Systems '87 (June 23–26 in Washington, D.C.).

George S. Borkovich, Conference Dir.
A/E/C Systems '87
Thorndale, Pa.

Four roads to parallel computing

In many cases, the difficulty of converting serial applications to parallel has been largely overstated ("Parallel computers diverge," Feb. 1987, p. 16). We have found that there are four distinct levels of conversion ease. First, *database searching* and *signal filtering* are very simple to convert because the program databases are regular and simple to partition into N nodes. Second, *fast fourier transforms* are more difficult to convert because node boundaries have to be transited more often, and the internode data communications system needs more attention. Third, *finite element analysis* is even more difficult because the physical irregularity of the databases makes them somewhat more critical to partition. And Fourth, *sorting* tasks are the most difficult to convert to parallel, because the popular algorithms that have evolved for serial processors are ill suited to parallel architectures. Users must therefore invent entirely new algorithms.

Al Kernek, Marketing and Sales Mgr.
Computer Research Division
Ametek
Monrovia, Cal.

Wanted: cooperative engineering programs

In "Wanted: hands-on engineers" (April 1987, p. 10), GE chief scientist Roland Schmitt mentions cooperative education in only two sentences. Most "dirt-under-the-fingernails engineers" complete only undergraduate educations. A truly cooperative education provides real experience in a real company with real equipment on real problems in a real engineering environment. For an engineer-in-training and a company, there is no better investment in the future than such a program. I strongly hope that the new congressional Task Force on Technology (of the House Science and Technology Committee) will examine potential federal actions to enlarge these valuable cooperative education programs.

Jordan J. Baruch
President
Jordan Baruch Associates
Washington, D.C.

Desktop chemical databases

In "Passing the word on toxic chemicals" (Feb. 1987, p. 61), you stated that "one problem is that U.S. producers lack a single chemical safety database that includes the information on every OSHA-regulated chemical" and clearly indicate the need for computer-based tools. Van Nostrand Reinhold's Chemtox is the first desktop database that contains data on all of these compounds in over 100 data fields for more than 3500 regulated chemicals.

Richard Pohanish
President
VNR Information Services
New York, N.Y.

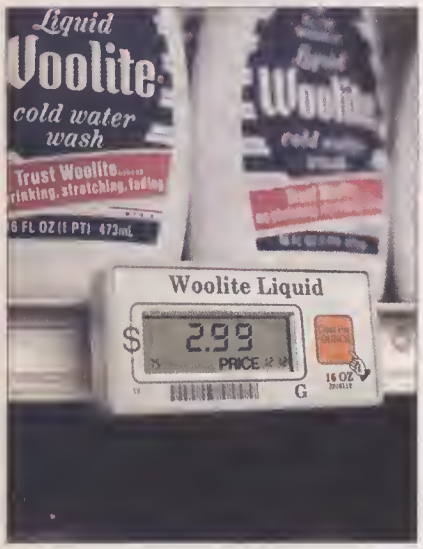
Piecemeal automation is no solution

"Flexible manufacturing systems: curing the cure-all" (Oct. 1986, p. 22) could be interpreted as encouraging our managers to scale down the use of advanced manufacturing technology and use piecemeal solutions to our productivity problems. This sends the wrong signal at the wrong time to managers and engineers across this country. Some companies have had problems in their application of flexible manufacturing technology, but these often occur because of poor system implementation (when the people are forgotten) or introduction of the technology through "islands of automation." Both approaches restrict full implementation, integration, and productive use of advanced manufacturing technology.

V. Daniel Hunt
President
Technology Research Corp.
Springfield, Va.

We welcome comments from our readers. Please address letters to Editor, High Technology, 38 Commercial Wharf, Boston, MA 02110. Or send to MCI Mailbox: HIGHTECHLET (617) 262-6468.

INNOVATIONS



Computer-controlled shelf labels take the legwork out of inflation.

Electronic price tags for supermarkets

Although bar code scanners have spared supermarkets the trouble of marking prices on each individual can of peas, the stores still devote a lot of labor to maintaining their shelf labels. Radio-controlled electronic tags now being tested offer an alternative. The liquid crystal display modules, developed by Telepanel (Markham, Ontario), receive signals from a transmitter hooked up to the store's main computer. Any price change entered into the computer will update not only the checkout scanners but also the shelf tags, ensuring consistency between the price marked and the price charged.

When the customer pushes a button, the display shifts from product price to unit price (say, cost per ounce or per gallon), making it easier to compare the value of different-sized items. The modules record the number of times their unit prices are requested; by comparing these numbers with the checkout scanner tally, a store can better assess the price sensitivity of its wares.

The units transmit as well as receive. For example, a stock clerk could manually set a readout in the corner of the tag to show how many of an item were missing from the shelf; this number could then be relayed to the computer to help the store keep track of inventory. The system has been in trial use since September at Loblaws supermarket in Toronto and since March at a Kroger in Carrolton, Tex. With more than 13,000 scanner-equipped supermarkets in the U.S. and Canada (according to the Food Marketing Institute), the potential market for systems like Telepanel's may be as high as $2 billion.

Blood test spots all forms of cancer

Researchers at Beth Israel Hospital in Boston have devised a blood test that signals the presence of cancer anywhere in the body. Although it can't determine which part of the body is afflicted, the test provides doctors for the first time with a way to screen people at risk for developing the disease.

The Beth Israel test relies on the analytical technique known as magnetic resonance spectroscopy, in which magnetic fields and radio-frequency energy are used to generate spectra that are unique to the molecules being studied. In this case, the technique analyzes lipoproteins—molecules in the bloodstream that consist of both proteins and fats. The researchers have found that the lipoprotein spectra of cancer patients differ from those of normal subjects. "We don't know exactly why this is so," says Eric T. Fossel, associate professor of radiology at Beth Israel, "but we think that the presence of cancer cells somehow alters the fatty portion of the molecule."

Early studies suggest that the test is more than 90% accurate in spotting cancer, says Fossel, and so far no form of the disease has eluded detection. The technology has been licensed to Siemens Medical Systems in Iselin, N.J., for further development; large-scale human trials will probably begin later this year, and Siemens may introduce an investigational (research-only) device by year's end. Fossel envisions a fully automated device for hospitals and clinics—available within five years—that could run cancer tests for about $30 each.

Hydraulic drive takes the strain off bus engines

Every time a bus accelerates from a stop, its noise and pollutant levels soar and its fuel efficiency plummets. Swedish vehicle maker Saab-Scania believes it can ease all three problems with its new "pressure accumulator drive" (or TAD, from the Swedish), which stores energy during deceleration and releases it to power the bus when it starts up again. In tests, the system not only permitted quieter, cleaner starts but also cut overall fuel consumption by a third.

TAD consists of a hydraulic mechanism that doubles as a pump and a motor, plus a "pressure accumulator"—a cylindrical tank that contains a piston with nitrogen gas on one side, hydraulic oil on the other. A chain drive connects the pump/motor to the bus's drive shaft. When the brakes are applied, the system's control computer activates the pump mode. Turned by the drive shaft, the pump pressurizes the oil in the accumulator tank. This forces the piston to move, compressing the nitrogen gas. Then, when the driver releases the brake and begins to accelerate from a full stop, the microprocessor switches the pump into its motor mode while holding the bus's diesel engine at idle. The compressed nitrogen then drives the piston toward the hydraulic oil, forcing the oil through the motor, which spins the drive shaft. At 19 to 25 mph, the diesel takes over. Monitoring vehicle acceleration, engine speed, and the output of TAD's hydraulic motor, the control computer switches to diesel power earlier if it senses a gradient or load that TAD can't handle, thereby avoiding sluggish starts.

Although it would work on other vehicles as well, TAD is ideally suited for transit buses because of their frequent stops. Already, about 10 of the systems are being tested in Sweden as part of a two-year evaluation program. Scania says it will eventually offer the system on its U.S. buses.

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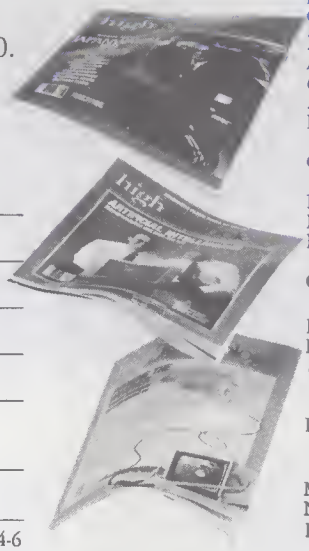

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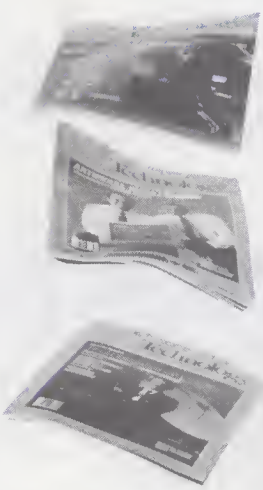

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INDUSTRY NEEDS INSURED LOANS

BY EDWIN LEE
CHIEF EXECUTIVE OFFICER, PRO-LOG CORP.

U.S. industry continues to lose ground in international competition. In electronics, for example, we have gone from being a $27 billion net exporter in 1980 to a $2 billion net *importer* in 1986.

Some manufacturers, blaming the situation on unfair practices by Japanese competitors, have filed lawsuits and supported restrictions on Japanese products. They have essentially demanded that government intervene to protect them.

Unfortunately, the problem is more fundamental. The basic challenge for American industry is to pay the relatively high wages, parts costs, and other expenses of doing business in the U.S., while maintaining rigorous standards of quality and service.

Although we certainly couldn't emulate all the conditions that prevail in Japan—nor would we need to—there is one important factor in Japan's industrial success that could well be adopted in the United States: a financial system that leverages investment in automation at rates of up to 40% of a company's annual sales. According to a recent report by the Defense Science Board, comparable U.S. electronics companies average less than a 22% investment rate. This is a result of our tying up capital in inventory, and being limited by "prudent" banking rules to conservative ratios of debt to equity and debt repayments to earnings.

The government could dramatically improve available credit for automation if it established a self-funding insurance system for capital equipment loans, like the Federal Housing Authority (FHA) program established in the 1930s to encourage home loans. Such an authority, perhaps called the Federal Capital Equipment Authority (FCEA), would insure loans made by banks and other private lenders for capital equipment that contributed significantly to automation.

Qualifying equipment would include computers, robots, engineering workstations, office automation networks, and other appropriate systems for factories and offices. The terms and duration of an insured loan could be determined by the FCEA based on appraisals that took into account the equipment's quality, compliance with health and safety standards, selling price, and market acceptance.

Certain financial guidelines would also have to be met by the borrower, but they could be looser than those currently imposed by lenders. For example, insurable loans might be limited to 50% of a borrower's total capital equipment. The guidelines would have to be designed so that some marginally profitable (or slightly unprofitable) companies in fiercely competitive industries could automate more vigorously. As it is, those most in need of automation are least able to finance it.

The lender would hold a mortgage on the equipment until the loan was paid off. If the borrower were to default, the lender would go through a foreclosure procedure and then resell the equipment. An annual FCEA insurance fee of about 1½–2% of the loan balance would probably provide an adequate margin to cover failed loans. Because the lender would be fully protected for the insured portion of the loan, interest on the loan could be pegged close to prime rate plus the insurance costs. The insured mortgages would be readily negotiable assets for lenders.

With the loan fully secured by the equipment and the insurance, the borrowing company could report as debt only the next 12 months of loan payments. This would upgrade the company's credit position and make additional conventional financing possible.

The FCEA program would have several positive effects:

- It would enable manufacturers to begin automating at a rate approaching that of Japanese industry, thereby creating additional demand for automation equipment along the way.
- Loan appraisal requirements would stimulate higher quality and safety levels for capital equipment across the board, just as improvement in all building codes has been a benefit of FHA even though it finances only about 30% of homes.
- The banking infrastructure would be strengthened. In contrast, solutions involving large government loans or the creation of government-funded companies tend to undermine the diversified business structure that is one of our greatest competitive assets.

But the FCEA program could also pose some problems:

- It might be used to force "Buy American" policies, regardless of the quality of the capital equipment.
- It might be viewed by some borrowers as a substitute for prudent credit decisions and good financial management. While the program would give lenders and borrowers more options, it would not prevent them from squandering those options.
- It might put some people out of work as automation continues to eliminate traditional jobs. This is a preferable alternative, however, to job displacement from foreign competition.

While these problems can be readily addressed, the FCEA suggestion is only one part of a long-term solution. Such a program could be expected to stimulate demand and provide U.S. industry with a three- to five-year demand-driven breathing spell. Meanwhile, long-term competitiveness would also require a change to just-in-time relationships among manufacturers, suppliers, and customers. Without such a change, additional capital could wind up supporting inventory rather than automation.

Over the last three years, for example, my company has developed a just-in-time program with three vendors: a printed circuit board manufacturer and two suppliers of electronic parts. This program, in addition to supporting automation goals, has improved overall inventory turns from under two to over five, reduced overall purchasing costs by over 40%, and substantially improved product quality.

For our company, this program is just the beginning. Among other things, we plan to double our shipments (in dollars per employee) over the next five years. Our analysis shows that such objectives are necessary to maintain all design and production functions in the United States and still remain competitive in international markets. If we could increase our rate of automation through a program such as the proposed FCEA plan, we could easily meet our goals. □

Pro-Log Corp., based in Monterey, Cal., is a manufacturer of computer products for industrial control.

The garden slugs in a microelectronics lab at AT&T Bell Laboratories are very fussy eaters. They won't go near their favorite foods if they smell a whiff of garlic. Garlic? Garden slugs? What could that possibly have to do with making computers smarter? More than you'd ever imagine...

Slug as savant: "Nature has shown us there are powerful computer designs very different from conventional machines."

The common garden slug loves the enticing odors of carrot, tomato and mushroom. But it hates garlic. When scientists at AT&T Bell Laboratories "spike" these favorite foods with garlic, what happens? The slug learns. It alters its memory of the foods it once loved and avoids or rejects them.

Insights gained from studying simple central nervous systems like the slug's point to a dramatically new approach to computing. An approach that promises to make computers faster, smarter and easier for people to use.

Why study slugs? Though the slug is no Einstein, its brain's limited ability to learn—to associate new information with existing memories—makes today's most powerful computers seem primitive.

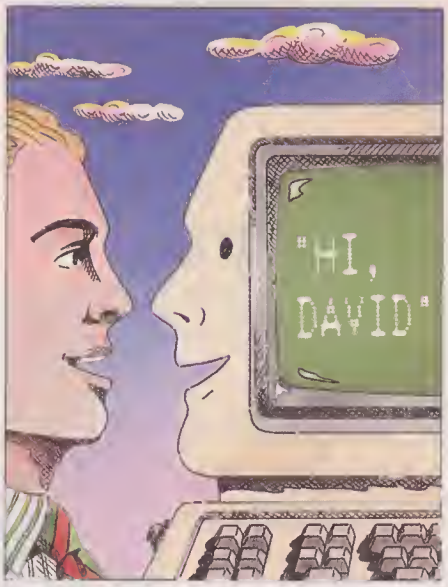
And the slug, with its neural networks comprised of a mere 500,000 nerve cells or neurons, is much less complicated to work with than people or other animals.

Microchips that mimic the brain

On functioning computer chips, microelectronics researchers have built prototype electronic neural networks.

Like biological networks of brain nerve cells, these electronic circuits use associative memory to relate incoming information to memories already stored. So they can cope with information filled with errors or ambiguity. And they can deal with "messy" information, collecting scattered facts to recognize and remember from incomplete details, much as the brain does.

One test chip, containing 54



In the future, people and their computers will have a much friendlier working relationship.

"neurons" in such a "neural network," can recall memories from imperfect data within a few millionths of a second—selecting "James Lynn" from among several stored names as the correct response to the input "Jim."

Getting up to speed

By studying simple central nervous systems like the slug's, scientists at Bell Labs are also gaining valuable insights into another brain function, parallel processing. It offers an answer to a physical limitation of today's computers—speed.

Step-by-step computing can only process information one piece at a time. Parallel processing, the ability to perform several functions simultaneously, speeds things up. And the more things done together, the faster the whole job gets done.

"Thinking" computers

Where is this research into associative memory and parallel processing leading? To "thinking" computers that make good judgments as well as good calculations. Computers that can perceive and learn in an imperfect world, much as people do.

In the future, working with computers will be more like working with people. The machines will understand and respond to human speech—even recognize the person addressing them.

Taking the longer view

Research scientists at AT&T Bell Laboratories are expected to take the longer view. To look beyond the impact of technology on the next quarter or the next year, into the next century.

It is this perspective that has produced seven Nobel Prize winners for Bell Labs. Some 21,000 patents, an average of more than one a day. And a legacy of achievement, from the transistor and the laser to lightwave communications and the digital computer.

This longer view ensures that the technology built into all AT&T products can evolve and adapt to the changing needs of the real world. Making information easier to obtain and use for everyone.

Today's computers can only process neatly-stored information. A little human ability to deal with messiness might actually make them a whole lot smarter.

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CYPRESS SEMICONDUCTOR:

PROSPERING DESPITE THE CHIP SLUMP

In recent years, many U.S. semiconductor companies have absorbed heavy losses, running their plants well below capacity in the face of a slowdown in demand and a surge of cut-rate imports. One of the few domestic firms to prosper in spite of industry trends is Cypress Semiconductor (San Jose, Cal.). Cypress has used high-speed complementary metal-oxide semiconductor (CMOS) technology, in conjunction with a heavily automated manufacturing process, to develop a variety of specialized, relatively expensive chips sold to niche markets.

While CMOS and the other prevalent forms of wafer fabrication—bipolar and NMOS—all yield high-speed circuits, CMOS chips require the least amount of power. Therefore they stay cooler, allowing for a greater density of components on a smaller area. Moreover, unlike bipolar circuits, CMOS chips get four times as fast whenever transistor size is cut in half. These factors make high-speed CMOS chips attractive for use in minicomputers, telecommunications equipment, and military systems.

Cypress manufactures 72 high-speed chips in four product categories, which vary in storage capacity and configuration. The company's static random-access memory (RAM) chips, for example, are used as auxiliaries to the main memories of computers, storing information that is currently being processed. Other product lines are devoted to such functions as storing permament data, carrying out floating-point mathematics, and digital signal processing. Among Cypress's customers are Wang Laboratories (which uses a static RAM chip in its VS line of computers), Digital Equipment, Apollo Computer, Intel, AT&T, and Texas Instruments.

In order to keep the competition at bay, most of Cypress's chips represent no more than a potential $40 million market. "Such markets are too small to entice large vendors, including the Japanese," says T. J. Rodgers, president of Cypress, "but cumulatively add up to a respectable size." Last year the company's sales were $51 million, triple the 1985 level. Cypress's profitability has been aided by the use of automated machinery throughout the production process. Robots, for example, are used for loading and unloading wafer cassettes, and for inserting each chip into any one of 65 different package types. "Our robots can package circuits several times faster than humans could," says Richard Goss, Cypress's VP for product development. "Without this capacity, we would have to send the chips overseas for assembly."

Cypress president T. J. Rodgers says the company has profited by selling specialized chips for digital signal processing and other niche markets.

"While Cypress has been a pioneer in high-speed CMOS processing, it may be difficult for them to sustain a leadership role," says Andrew Rappaport, president of Technology Research Group (Boston). "Technology changes rapidly, and the company has a heavy investment in its present equipment." Moreover, at least one major competitor—Integrated Device Technology (Santa Clara, Cal.)—and several start-ups have entered some of Cypress's markets with high-speed CMOS devices. However, says Rappaport, Cypress is in a good position to benefit from a growing preference for CMOS chips, which will replace their biopolar counterparts in many applications over the next few years. Paul Johnson of L. F. Rothschild (New York) estimates that the $200 million high-speed CMOS market will grow at a 50% annual rate over the next two years. Cypress intends to keep up with such demand; Rodgers says that the company plans to release at least a dozen new chips within the next few months. □ ***—Patricia Hittner***

PETROFERM:

BIOPOLYMERS FOR INDUSTRY

Oil and water don't ordinarily mix. That may change if Petroferm (Fernandina Beach, Fla.) has its way. The company uses modified forms of biopolymers (chemicals secreted naturally by microbes) to help force oil and water together, creating expanded applications for heavy crude oils or oily wastes. Using similarly modified biopolymers, the six-year-old company is also developing products that can speed oil-well production and clean contaminants off microchips and printed-circuit boards.

Petroferm bases its technology on the ability of biopolymers extracted from *Acinetobacter calcoaceticus* and related microbes to adhere to, and dissolve, oil. The biopolymers can then be used as emulsifiers, creating stable mixtures out of water and tarry oils, such as the asphalt sludges left over after crude oil is refined. Early this year, Petroferm announced the commercial availability of its biopolymers for producing "pre-atomized fuel" (PAF) from such oils. A licensing agreement has already been signed with Steuart Petro-

CINDY CHARLES

leum Co. (Washington, D.C.), an independent marketer and terminal operator of refined petroleum products.

"The PAF produced from a refiner's bottom-of-the-barrel residual products is equivalent to No. 6 fuel oil," explains William Galloway, chairman of the firm. This grade of fuel oil, widely used in boilers and furnaces, is usually produced by mixing asphalt with lighter oils or even refined kerosene. The PAF process substitutes water (up to 30% of the final mixture) and the firm's proprietary emulsifiers for these higher-value diluents. "PAF is cost-competitive with No. 6 oil, and gives the refiner the option of selling his higher-value products to other markets," says Galloway. Moreover, burning PAF produces half the nitrogen-oxide and particulate emissions of traditional fuel oil.

"Petroferm's technology for PAF is especially useful for refiners who don't have a ready market for their residual asphalt," says John Dosher, managing director of Pace Consultants, a Houston energy and petrochemical advisory firm. Dosher explains that most such asphalt is marketed for roadways, but it can't be economically transported very far because of its weight and viscosity. Where refiners tend to congregate, as in Houston, Louisiana, or Philadelphia, the local market is oversupplied with asphalt. Dosher notes that the No. 6 fuel market is quite large, amounting to 1–2 million barrels per day in the U.S.

Biopolymers help turn sludge into fuel oil that can be used in boilers.

Petroferm's biopolymers are also used in down-hole emulsification (DHE), a process that increases production from heavy-oil wells found in California, western Canada, and Venezuela. These wells, which currently use such techniques as steam or water flooding to coax the viscous oil from the ground, can double their daily production with Petroferm's products, according to R&D director Michael Hayes. "The biopolymer expedites the flow of oil from the well bottom to the surface, thereby cutting the well's production costs over its active life," he says. DHE has been field-tested by Dome Petroleum and Amoco Canada; a major test at a 100-well oilfield is currently under way.

The utility of both PAF and DHE are dependent on swings in the world price of crude oil. To offset this dependency, Galloway has pursued market opportunities for biopolymer-based products in other sectors as well, particularly electronics manufacturing. The company has a family of cleaning solutions brand-named Bioact that are used by the makers of printed circuit boards and microchips to remove such contaminants as the baked-on flux created when electronic components are soldered to the board. Hayes believes that Petroferm's cleaning solutions, unlike conventional cleaners, are especially effective in removing the flux from surface-mounted chips; with surface mounting, the clearance between the chip and the circuit board is much less than on traditional boards. "As surface-mount technology becomes more popular," says Hayes, "Bioact should contribute a significant portion of our earnings." □ ***—Nicholas Basta***

FERTILITY & GENETICS RESEARCH:

NONSURGICAL OVUM TRANSFER

As many as 14% of all couples of childbearing age in the U.S. may face serious difficulty having children: almost half of this group consists of women who are infertile or who fear that their own children would inherit genetic diseases. Fertility and Genetics Research (FGR) was formed in Chicago by a group of physicians and entrepreneurs to develop a nonsurgical technique that could remove a fertilized ovum from the uterus of one woman for transfer to that of another woman.

Although the technology for artificially inseminating women with sperm has been available for several decades, the technology for transferring egg cells was developed only recently. In a typical case, an infertile woman's husband provides sperm to inseminate the donor, who is selected on the basis of physical similarity to the infertile woman. After a few days, a catheter is used to flush out the uterus and capture the fertilized ovum (the device contains a fluid designed by FGR to protect the ovum); the ovum is then introduced into the recipient's uterus, where it grows and is delivered as if it were her own genetic baby.

Alternatives to ovum transfer are available, particularly when the problem is that egg cells are not released from the ovaries, but each has drawbacks. *In vitro* fertilization—which involves surgical removal of the ovum from the mother, fertilization and several days' growth in a test tube, and implantation back into the mother—carries a low success rate and high cost. A woman can also be treated surgically or with a variety of drugs to stimulate ovulation. However, surgery is expensive and risky, while drugs may either not work for some women or induce multiple births in others. An adopted infant, of course, will not bear either parent's genetic traits, and contests over a child born to a surrogate mother can be traumatic.

FGR claims that ovum transfer, which has an estimated success rate of 10–20%, is simpler, safer, less costly, and considerably easier to repeat, if necessary, than other methods. But the company has had to back off from its original plan for implementing this technology. Under the assumption that ovum transfer would become the leading method for overcoming fertility problems, FGR had intended to establish a group of specialized clinics in the U.S. and Europe linked by a computer network that would provide information on potential donors. Two developments have put a brake on this strategy. One is a variation on *in vitro* fertilization that uses an ovum from a third-party donor. In either type of *in vitro* method, the woman providing the ovum—whether the mother-to-be or a third party—is first treated with hormones that allow many eggs to be obtained at once. Because implantation seems to work better in a woman who has not been taking these hormones, the newer *in vitro* method appears to offer a higher success rate. The other hitch in FGR's plans is the rising fear of AIDS, which could affect demand for any donor-based fertility process, including ovum transfer.

The company faces a number of other problems, as well. FGR has been granted a patent for its catheter device, and although it has applied for patents for the entire ovum transfer procedure, the absence of full patent protection could enable other medical researchers to develop similar or improved means for transferring ova. Donors might sue the company for infections caused by the procedure, for ectopic pregnancies (fertilized eggs lodging in the Fallopian tubes), or for any other abnormalities connected with later childbearing; recipients might demand damages for any birth defects attributed to the procedure. To make matters worse, there are also uncertainties about how states will interpret lawsuits regarding legal parentage.

The technology for transferring a fertilized ovum from one woman to another may be licensed to fertility clinics.

But Fertility and Genetics Research is confident that its procedure will prove safe, and that legal precedents established for artificial insemination—for example, a sperm donor is not held to the rights and responsibilities of fatherhood—will serve as a guide to disputes over ovum transfer.

FGR is now considering two complementary options for marketing ovum transfer. One would involve licensing its technology to free-standing or hospital-based fertility clinics to use as one among several options available to patients; the 130 *in vitro* clinics in the U.S. are one potential group of customers.

Another, more ambitious possibility is for FGR itself to establish "full-service" fertility clinics at hospitals. "Reproductive technologies have merged more quickly than anyone expected," says Lorraine Maxfield, analyst with Paulson Investment (Portland, Ore.). She estimates the potential market for such techniques at $400–475 million annually. "So it now makes sense to position ovum transfer as one of the choices—but not necessarily the only choice—open to infertile couples." □ ***—Jeffrey L. Fox***

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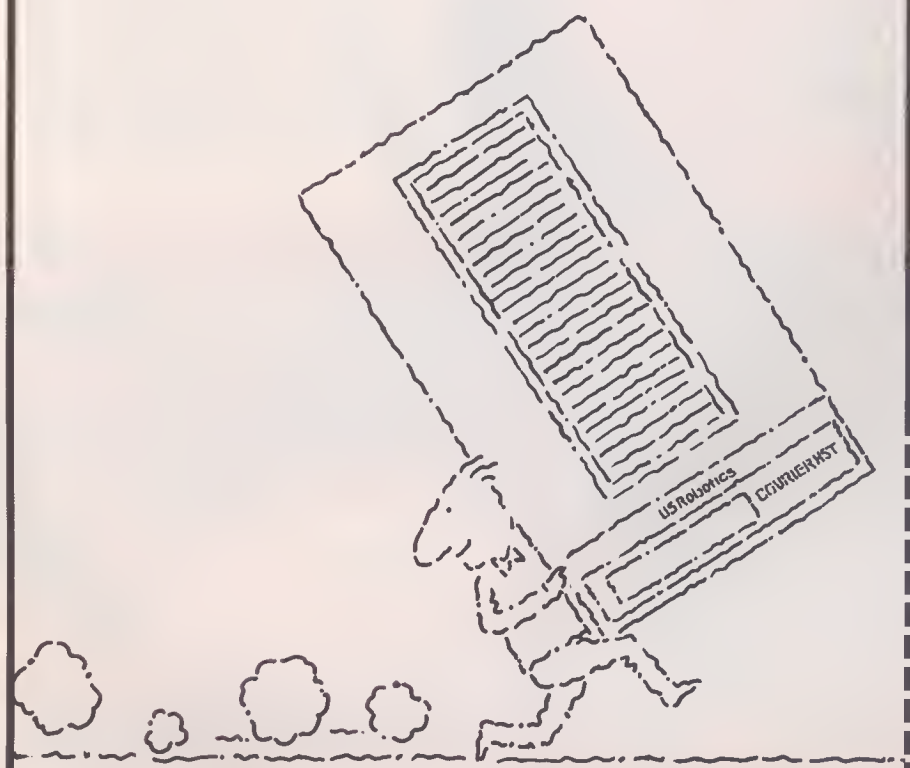

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BELL LABS SPINOFFS

Former AT&T researchers parlay their technical expertise into a broad spectrum of start-ups

BY MARIAN S. ROTHENBERG

In its constant search for better telecommunications technologies, AT&T Bell Laboratories has generated products as diverse and influential as the transistor, the laser, the UNIX operating system, and a test for lead poisoning. Less publicized has been the laboratories' role as a wellspring from which Bell Labs alumni have flowed out to start their own entrepreneurial firms. This effluence of talent from the research facility is more of a trickle than a torrent, and it probably won't come close to draining the labs' resources. In fact, some say it may benefit the overall U.S. economy by serving as an effective way to transfer to the marketplace those technologies and products that might otherwise be neglected or delayed in the labs.

When it was a highly profitable monopoly, AT&T couldn't always realize the full economic benefits of its laboratories' developments, because the company was restricted from entering markets such as computers and microelectronics. With the breakup of the Bell System, many of these restrictions were lifted, but the company has still had difficulty establishing itself outside of its core business: long-distance telecommunications services

and telephone equipment.

Bell Labs survived the divestiture relatively intact despite cutbacks and retrenching at other parts of AT&T. Direct comparisons of the Bell Labs research budget before and after divestiture are difficult, however, because AT&T now prefers to talk about total company R&D. The Bell Labs research allotment is currently about 7.5% of AT&T's $3 billion total R&D budget, estimates Arno Penzias, VP for research at Bell Labs; before divestiture, the research funding was about 10% of Bell Labs' $2 billion overall budget. So funding remains high, and the labs continue to work at the forefront of many research disciplines. But a growing number of its scientists have elected to take their expertise directly to the marketplace via the products of their own spinoff firms.

These firms are engaged in a range of activities, including fiber optics, advanced semiconductor fabrication, and enhanced network services. Likewise, their founders left Bell Labs for a variety of reasons, although all obviously saw market opportunities for certain evolving technologies. The founders also share strong technological credentials, with which they've been able to lay the groundwork for their new firms.

Still, despite the technological smarts and the prestige that people can gain from a stint at Bell Labs, much of the venture capital community is adopting a wait-and-see attitude toward the start-ups' chances. Bell Labs people are "some of the smartest people in the world," says Douglas Carlisle, a general partner with Menlo Ventures (Menlo Park, Cal.), who notes that they also seem very committed to the work ethic. However, he cautions, they often don't have much experience in soliciting and acting upon marketplace feedback or in supporting products. And few have ever managed a business; rather, their programs were considered "loss centers" and were simply given a budget. On the plus side, says Carlisle, "they are good at estimating costs and manpower." He believes that this knowledge must be supplemented with management experience and by an understanding of the financial realities of profit and loss and cash flow.

Harry Edelson, a general partner with Edelson Technology Partners (Saddle Brook, N.J.), agrees: "We like to see Bell Labs people teamed up with people who have small-business experience." Still, he has been impressed by the founders' unrivaled technical expertise; he estimates that Bell Labs people may have $20–30 million worth of knowledge invested in them. Nevertheless, says Edelson, much of this knowledge is based on the requirements of the telephone industry and the defense market and may not be applicable in other industry sectors.

BUILDING A TEAM. One start-up that took the venture capitalists' advice to heart was Silicon Design Labs (SDL), which recruited a marketing manager from Apple Computer to join the other four founders, all former Bell Labs researchers in computer technologies. Hal Alles, SDL's VP of integrated circuit design, had been at Bell Labs for 11 years. He had been director of computing technology research for two years, when he left in February 1983 to found the company. Three of the other cofounders—Misha Buric, Carl Christensen and Tom Matheson—had collaborated on PLEX, a research project aimed at computerized automation of integrated circuit design. Founded with a goal of producing design software for the custom chip market, SDL merged with Silicon Compilers (San Jose, Cal.) in March of this year to form a new company, Silicon Compiler Systems.

Before leaving Bell Labs, says Alles, "I was taking a number of the technologies we had in research and trying to find an application for them." But he ran into myriad reasons why these technologies couldn't be transferred into development organizations. He felt frustrated at not seeing the work of his own laboratory put to use, and he believed that AT&T as a whole would have a difficult time adapting to the new competitive environment that came with divestiture. The four Bell Labs staffers decided to form a company to serve the IC design market, which they expected to be a strong one.

From the beginning, the SDL plan called for flexibility. "Anytime you develop a company to serve a market," says Alles, "you don't really know what you have until you go out and test the market." Because of the founders' limited business experience, they took on Peter Rip, the Apple marketing manager, as a fifth cofounder. They have since added other management personnel with a range of corporate backgrounds.

SDL's goal was to automate every stage of integrated circuit design—from the initial concept of the chip's function to the physical layout of the transistors, with simulation and testing tools for every step, according to Alles. The firm's most comprehensive product, GDT (Generator Development Tools), is intended primarily for experienced IC design engineers working for semiconductor manufacturers. GDT includes a "silicon compiler compiler," which captures the knowledge of

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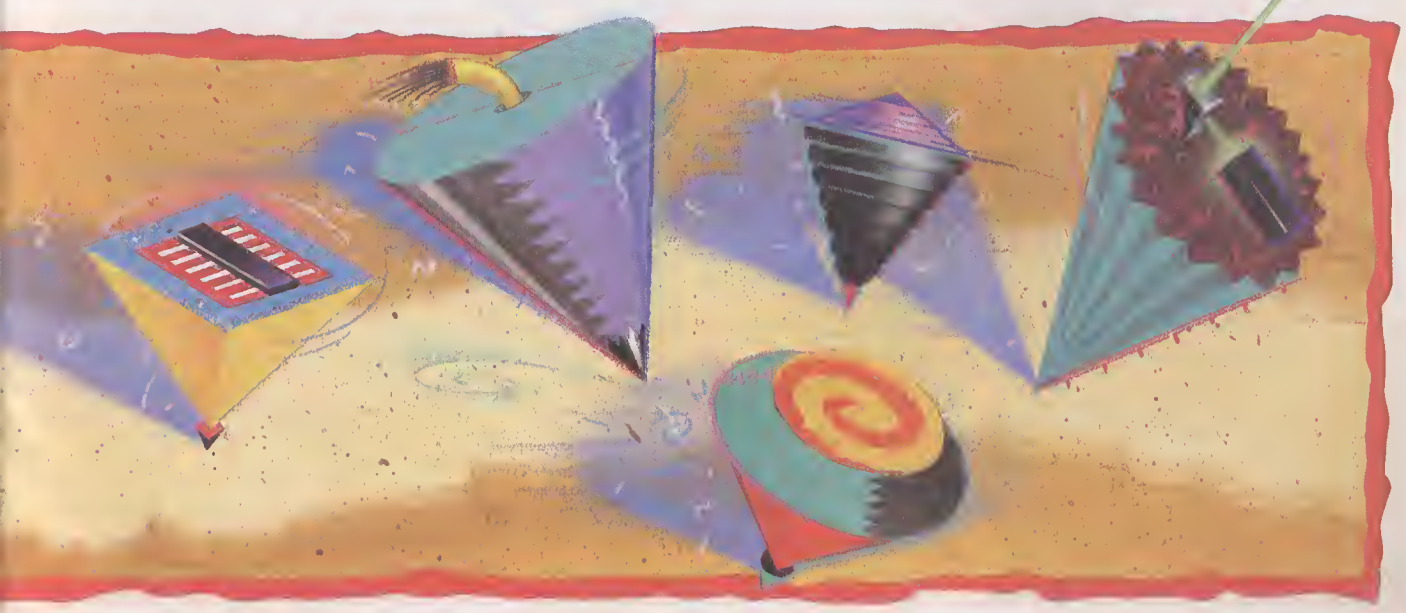


veteran designers so that a single IC layout can be reused to generate customized versions of the chip. But to remain flexible in response to market demands, says Alles, SDL has structured its product line so customers can buy the piece that fits their needs. The company also provides design services for the booming application-specific integrated circuit (ASIC) industry.

NOT INVENTED HERE. Whatever their reasons for leaving Bell Labs, most of the new entrepreneurs feel it was a good place to work. "The best decision I ever made was to go to Bell Labs," says Raymond Dingle, president and CEO of Gain Electronics. In particular, he applauds the Bell Labs policy of moving people around to broaden their scientific knowledge. Nevertheless, he says, "the next best decision I ever made was to leave." He departed because AT&T appeared unable to decide whether or not to capitalize on work in his field—gallium arsenide (GaAs) devices. A self-styled risk taker, Dingle says he's "convinced that there's a commercial marketplace for these products. This is the acid test—to get out there and find out."

One Bell Labs characteristic Dingle criticizes is "NIH," or "not invented here"—a prejudice against technology or ideas that didn't originate within the labs. Repudiating this attitude, Gain was able to manufacture its first commercial product, an ASIC chip set aimed at a segment of the instrumentation business, even before its 8000-square-foot cleanroom was built; the company used the facilities of a "friendly foundry." Dingle cites this as an example of the "you don't have to invent everything yourself" principle. "Our job in this new business is to commercialize something and earn a profit."

Dingle, an Australian-born chemist, came to Bell Labs in 1967. He moved through various research disciplines, helping to build an early molecular-beam epitaxy machine for materials research, then using it to grow semiconductor films just a few angstroms thick (one angstrom equals one 10-billionth of a meter). In 1979 he transferred to development and used the films to build devices that allowed the speeded-up flow of electrons; in 1983, Bell Labs made him a Fellow for his work on these fast GaAs transistors. (The Fellows program rewards those who have made major contributions to R&D.) In August of the following year, Dingle left to found Gain, receiving support from Mitsui, a Japanese trading company, as well as some U.S. venture capital.

In addition to Dingle, Gain's management now includes several others from Bell Labs. Russ Buckley, vice-president of operations, came directly from 20 years as a Bell Labs industrial chemist; Charles Lee spent 11 years there working on microprocessor design. He then worked for two years at Bell Communications Research, the research arm of the divested Bell Operating Companies, before moving to Gain.

Gain hasn't severed all ties with AT&T—it holds a patent license agreement with the company, covering all GaAs and lightwave-device technology. In addition, the firm has a technology transfer agreement with Japan's Nippon Telegraph & Telephone. By the end of this year, Gain expects to have built 4-kilobit GaAs memory chips based on NTT technology.

LIMITED OPPORTUNITIES. A direct counterpoint to Dingle's experience at Bell Labs is that of Raymond Jaeger, who left in 1976 and is now president of Spectran, the publicly traded fiber optics company he founded in 1981. Jaeger felt that his work in fiber optics was too *much* a part of the mainstream at Bell Labs, so there were few available management positions.

Jaeger, who came to Bell Labs in 1959 with an undergraduate degree in ceramic engineering, benefited from a tuition reimbursement and work support program leading to a PhD in 1967. He worked in all aspects of Bell Labs' optical fiber research program. Looking back on those days, he recalls, "We had a lot of competition for patents, internal and external." He helped develop a practical process for making optical fibers, and was impatient to follow this fiber work out of research and into the development process.

"The best decision I ever made was to go to Bell Labs. The next best decision was to leave."

But management did not follow up on his request, says Jaeger, so in 1976 he took advantage of a chance to become director of research at Galileo, an American Optical Corp. spinoff that was entering the optical communication business. By 1981, that market was on the verge of a boom, but Galileo's owners were about to sell off the division. As a result, Jaeger left and, with two colleagues, founded Spectran. His time at Galileo was a transition period, giving him the chance to learn small-business skills and gain experience in production and customer service.

Another researcher who served an apprenticeship at an interim company before starting his own was C. J. Hwang, who worked on lasers at Bell Labs from 1966 to 1973. Although he knew that he wanted to start his own company, Hwang went first to Hewlett-Packard in order to gain experience in transferring a product from research to production. In June 1977, after four years, he left to found General Optronics, a fiber optic component business. Hwang and a partner were financially backed by Insilco (International Silver Co.).

STUMBLING BLOCKS. For at least one Bell Labs alumnus, the path to entrepreneurship had some stumbling blocks of AT&T manufacture. Lytel, a maker of semiconductor components for fiber optic communication, was incorporated in 1983, when founder Eugene Gordon retired from his job as director of fiber optic device development at Bell Labs. (AT&T employees can retire with full pension rights at 55 if they have been with the company at least 20 years.)

Gordon's career at Bell Labs, which he began in 1957 with a PhD in physics from MIT, included work on the first gas lasers, medical lasers, and technology for semiconductor manufacture. In the '70s he held a position that required him to act as a liaison between component developers and system designers, and in this role Gordon acquired business skills such as performing cash flow analyses and reaching make/buy decisions. "Of all the jobs I had at Bell Labs," he says, "that was probably the one I was least suited to do in terms of qualification and training, and the one I did best."

In 1983, four years after returning to a technical job, Gordon decided to retire early and go into business on his own. He arranged backing from AMP Corp. (Harrisburg, Pa.), but Lytel's entry into the market was delayed by a threatened AT&T legal action. This was resolved in 1984 when Lytel and AT&T agreed to arbitrate any future claims about proprietary information, and Gordon agreed not to solicit any Bell Labs employees for a year. In April 1987, AT&T and Lytel signed a patent cross-licensing agreement for fiber optic components and systems.

Conflicts with entrepreneurial former employees over how to handle proprietary information and other isues are of constant concern at Bell Labs. All management employees sign an agreement that "reflects the long-standing policy and practice of AT&T that intellectual property generated by such employees during the course of their employment belongs to AT&T," according to a company spokesperson.

When they leave, employees are reminded of their obligation to continue to "safeguard AT&T proprietary information." But this restriction does not extend to the employee's "general knowledge,

PHOTOGRAPHS BY PETER VIDOR

L–r: Charles Lee, Raymond Dingle, and Russ Buckley in Gain Electronics' soon-to-be-completed cleanroom facility. The company will produce high-speed chips based on gallium arsenide technology.

Before his start-up firm, Lytel, could begin producing its fiber optic products, Eugene Gordon first had to resolve a legal action initiated by AT&T, his former employer.

skill, and experience." As a rule, employees who start up companies are not specifically deterred from hiring other Bell Labs employees—within limits. "If someone does start hiring a lot, then we would handle it on a case by case basis," says the spokesperson.

AT&T continues to grant licenses for many of its patents, but is no longer compelled to do so; the Modification of Final Judgment that took effect in 1984 between the Justice Department and AT&T eliminated this requirement of the 1956 Consent Decree. AT&T, which regards patents as assets, evaluates each licensing request on its merits and grants licenses only when it finds a business advantage to doing so. Several of the companies founded by Bell Labs alumni have been granted AT&T patent licenses, as has Lytel.

Lytel manufactures and sells its devices in a variety of forms, ranging from unpackaged components to complete transmitter and receiver systems. Customers decide what they need, says Gordon, but his Bell Labs experience in working closely with system designers sometimes allows him to provide guidance. For example, he is particularly en-

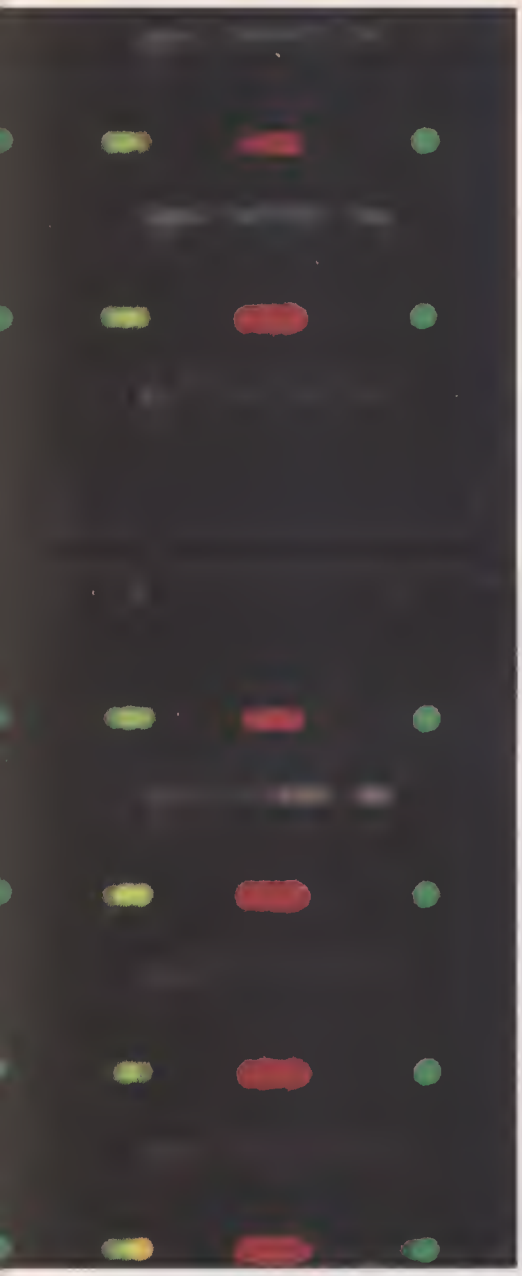
thusiastic about a new low-cost, low-power 1.3-micron laser aimed at the local-loop portion of the telecommunications market. (The local loop is the relatively short link between the local telephone office and the subscriber.) Because Lytel's laser is more powerful than light-emitting diodes, says Gordon, customers can use less sensitive receivers, thereby reducing overall system cost.

NO COMPLAINTS. Norman Schumaker, the founder of Emcore, had no complaints about Bell Labs or AT&T. "I think we're seeing a new class of technologies coming into the marketplace," he says, "and whenever that happens, people like me say 'Let's give it a shot.'" Just as the semiconductor era took shape in the '60s, Schumaker sees the '80s as a time when compound semiconductors, fiber optics, and enhanced computer technologies are poised for rapid growth.

As a supervisor in the semiconductor materials development group at Bell Labs, Schumaker realized there was a lack of good production equipment for fabricating gallium arsenide and other compound semiconductor devices. The idea of starting a company was always in the back of his mind, and Schumaker got financially savvy friends to show him how to raise the necessary capital. Then he and Bell Labs colleagues Richard Stall and Wilfried Wagner "just seized the opportunity."

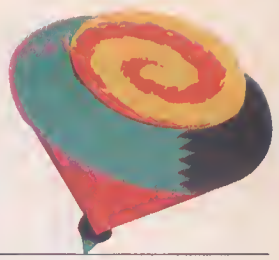
Schumaker left the labs in October 1984, having raised about $1 million in seed money, to start Emcore as a limited partnership. The company builds metal-organic chemical vapor deposition (MOCVD) systems for epitaxial wafer growth of compound semiconductors (HIGH TECHNOLOGY, Feb. 1986, p. 71, and March 1987, p. 38). Schumaker says he and his colleagues realize that they don't know all there is to know about every aspect of the business, "so we go out and find the specialists."

DIVESTITURE FALLOUT. For others, it was the breakup of the phone company that prompted them to reevaluate their positions at Bell Labs. This was the case with Jack Cook, whose decision to leave the



KEN KERBS

Part of an earlier exodus from Bell Labs, C. J. Hwang left in 1973. Before founding General Optronics, he spent four years at Hewlett-Packard gaining the skills needed to run his own company.



labs and start Dorran Photonics, a fiber optics company, was sparked by the announcement of the divestiture agreement. "I recognized that turmoil was ahead and that my own personal opportunities were not what they might have been," he remembers. There was to be "an exciting time ahead, but I could see that I wasn't going to play one of the exciting roles."

Cook retired from Bell Labs in 1982 and formed Dorran Photonics in May of that year. He knew that Western Electric, then the manufacturing arm of AT&T, had not yet managed to license an innovative fiber optic connector technology to a second manufacturing source. Upon his retirement, Cook immediately licensed the patents and, with money from family and friends, started Dorran. The company manufactures connectors for single-mode fiber—the type now most widely used in telephony applications—and sells them largely to the regional Bell operating companies.

Some aspects of the new business, such as learning about manufacturing, were demanding for Cook. "Just establishing the regimentation, the training, and the production criteria is a real chore," he says. Last December the company became a wholly owned subsidiary of 3M and is now called Dorran/3M; Cook has been made technology manager of the R&D division.

ELECTROPOLITICAL ISSUES. Tibor Szekeres had a much shorter career at Bell Labs than some of the other alumni-entrepreneurs. He left his job as a supervisor in 1982, after six years of working on a variety of transmission systems. He quit largely because he disliked spending time on "electropolitical issues" such as internal power struggles rather than on technology markets. When he formed his company, says Szekeres, he "bootstrapped from zero."

The company, General Communications Corp., is aimed at the infant Integrated Services Digital Network (ISDN) market. Worldwide ISDN standards are still being defined, but are intended eventually to allow simultaneous transmission of voice, data, and video traffic along a common digital link. Szekeres's company develops terminals, controllers, and microcomputer interfaces, all aimed at making existing customer equipment compatible with ISDN. His customers, he says, are network and system integrators.

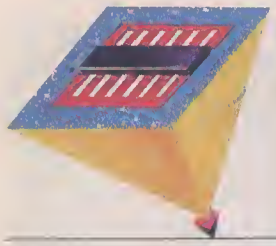
Like many of his fellow Bell Labs alumni, Szekeres, who serves as VP of engineering, takes pride in paying attention to customer needs. He spent six months evaluating what people wanted and how much they were willing to pay. "Our products are low-risk for the customer," he says, claiming that they can be used now, before ISDN is fully implemented, and continue to be useful regardless of how the standards evolve. The company's first ISDN-compatible product was shipped in late October. An earlier product, for monitoring telecommunications performance, has been providing revenue for two years.

AVOSS (short for "added value operating support systems"), founded in 1985 by Jim Ritchey, is also a child of AT&T's breakup. Ritchey started developing telephone sets at Bell Labs in 1959. He retired in 1982 as head of a department working on telephones for Charge-a-Call. With divestiture and deregulation, he saw an opportunity to provide enhanced services, such as voice store-and-forward, over telephone networks.

Ritchey, now president, and a partner—who had helped plan networks that allow Cincinnati Bell–area businesses to offer call-in services—have developed a prototype product: a network node system that will give advertisers and other information providers access to the customers of telephone networks. "Our potential partners," says Ritchey, "are the Bell operating companies, the independent telephone companies, and the long-distance companies." Although the company has no firm contracts, he says, negotiations continue and products could be delivered in the fourth quarter of 1987.

TIME FOR A CHANGE. A more recent member of the alumni-entrepreneur club is Martin Lepselter, who retired last December after 29 years at Bell Labs to found Lepton. Lepselter had been director of the Advanced VLSI Development Lab; his experience runs from basic device research through the entire range of semiconductor technology. His decision for leaving was unrelated to divestiture or dissatisfaction with the company, he says. Rather, "after 29 years, I just felt it was time to do something else."

Lepton will build electron beam systems for covering semiconductor wafers with the submicron patterns needed for the next generation of high-speed integrated circuits. He claims that this equipment will be capable of $\frac{3}{8}$-micron linewidths (the best semiconductor devices now commercially available have linewidths about twice that), will be economically competitive, and will be compatible with existing equipment. He sees the potential market as encompassing all semiconductor manufacturers, including some future entrants that may incorporate specifically to exploit Lepton's technology. With this technology, declares Lepselter, vertically integrated electron-



Bell Labs' Penzias says the AT&T divestiture merely hastened the departure of employees who would have quit anyway. Still, most have left for positive reasons, he says, rather than because of dissatisfaction with Bell Labs.

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Raymond Jaeger, President

* These four officers founded Silicon Design Labs, which merged with Silicon Compilers to form Silicon Compiler Systems.

ics companies will be able to manufacture their own chips.

EARLIER EXODUS. The current wave of Bell Labs spinoffs was preceded in the 1970s by a spate of resignations as people left to start fiber optics companies. Some, such as Jaeger and Hwang, served interim apprenticeships at other companies before striking off on their own. Others, however, were able to jump directly from the labs into entrepreneurial ventures.

At the time, fiber optics technology was on the verge of commercial application. Investment capital was not readily available, but back then fiber optics was not a very capital-intensive business. One of the start-up companies, Fiber Communication, could be capitalized at less than $70,000, partly from home mortgages. To Frank Dabby, one of the founders, leaving Bell Labs at that time and starting a company seemed natural. Bell Labs had ended the project he was working on and, he says, "if you've got an idea and you want to pursue it, the idea becomes the motivation—and you make money along the way."

In 1979, Dabby sold his interest in the company, by then merged into Times Fiber Communication (Wallingford, Conn.), and in 1980 he began a second fiber company, Lightwave Technologies. Now the fiber business in general has evolved to the point where it involves considerable capital demands, and Dabby is seeking investors.

While these earlier departures from Bell Labs occurred in response to the fiber optics boom, some of the more recent spinoff activity was prompted by divestiture. Penzias at Bell Labs plays down the significance of this latest wave, describing divestiture as merely "a precipitating event." Some people who might have gone out in 1987 or 1988, or even 1990, he contends, simply left earlier. "We're doing what Fairchild and Hewlett-Packard did for Silicon Valley," he says. "If a lot of our people left for jobs just like Bell Labs someplace else, I would worry. But if they leave to become university professors, or to start their own companies, then they're leaving for positive reasons, not negative ones."

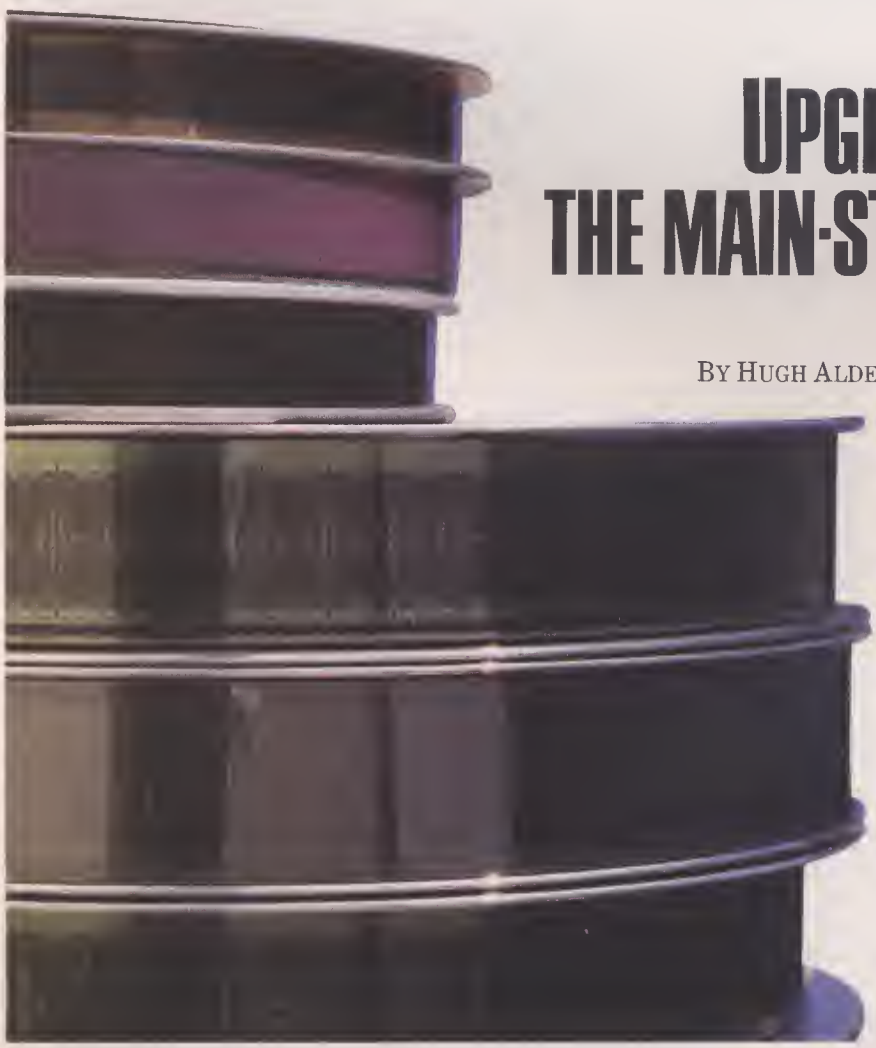
Meanwhile, there is some evidence that AT&T itself recognizes the advantages of an entrepreneurial approach in order to transfer new technologies to the market rapidly. For the past few years, the company has financed several "intrapreneurial" activities—businesses that operate in a quasi-independent fashion within the corporation. Originally grouped under the title of "new ventures," these activities are usually based on Bell Labs technologies that appear to have commercial potential in areas that lie outside the mainstream of AT&T's activity. Examples include systems for computerized speech, medical diagnostics, medical record keeping, and computer graphics. The head of each new venture is responsible for all aspects of the business, including product development, marketing, and sales. Through this approach, AT&T may be able to keep some of the more enterprising Bell Labs employees in-house, and may also provide more competition to those who have chosen to start companies of their own. □

Marian S. Rothenberg founded a high tech public relations firm in Montclair, N.J., after spinning off from Bell Labs and AT&T.

For further information see **RESOURCES**, *p. 66.*

COMING SOON TO A THEATER NEAR YOU

To hold its own against advances in consumer electronics, the film industry is working on new ways to dazzle the eyes and ears of moviegoers. America's main-street cinemas have already started converting to taller screens, novel projection systems, and digital sound. And the "special-venue" theaters at museums and other sites are more exotic still.



ROB LEWINE

UPGRADING THE MAIN-STREET CINEMA

BY HUGH ALDERSEY-WILLIAMS

American motion picture attendance has held steady over the last 10 years, and revenues in the film industry have actually risen, thanks to increased ticket prices. Still, in spite of statistics, producers and theater owners fear that the number of moviegoers may decrease in coming years unless films become more technologically competitive with home entertainment media.

In addition to facing pressure from cable television and videocassette recorders, moviemakers must cater to a clientele that's becoming accustomed to the high-fidelity sound of compact discs and that will soon be enjoying high-definition television. In response, the film industry is developing ways to improve picture quality. Moviegoers will see sharper images, in some cases on much larger screens. And sound quality is set to advance as researchers perfect methods for

encoding digital soundtracks directly on film.

CATCHING UP. The film industry has never been very technology-minded. Only a fraction of the research by members of the Society for Motion Picture and Television Engineers (SMPTE), based in Scarsdale, N.Y., is devoted to film rather than TV. The last major improvement in movies was the introduction of higher-resolution, 70-mm-wide film way back in 1956. But even today, more than 90% of movies are still shot on narrower, 35-mm film. Meanwhile, a few specialized technologies, including Imax, Omnimax, and Showscan (see accompanying article), have emerged as the only dramatic advances in motion pictures. But their use is limited, largely because they require expensive projectors and exotic theaters to show films shot with specialized equipment.

Rather than moving to such exotic systems, the industry is beginning to improve the motion picture quality of America's main-street theaters (there are nearly 23,000 movie screens nationwide) in increments that don't require large investments in new equipment. For example, digital movie sound now under development will use the same space along the side of movie film that currently carries analog soundtracks. Also, the SMPTE is considering a new standard that would raise the film speed at which movies are shot and projected. Some of these changes could be made simply by modifying existing equipment.

Improving movie quality through relatively inexpensive alterations is the strategy being pursued by FuturCinema Systems. The company's FuturVision 360 system was recently installed in Manhattan and the Meadowlands, N.J., by Loews Theaters, a leader in first-run movie houses, of which it owns about 300. The FuturVision system uses custom optics, electronic audio processing equipment, and a brighter light source. It also requires a larger screen. All these features can be retrofitted to existing facilities, making FuturVision much simpler and cheaper than more revolutionary special presentation systems, says FuturCinema president Eric Knutsen. "It has the tremendous advantage of being able to use a standard 70-mm projector," he says.

One aim of FuturVision is to achieve an effect of "picture dominance" through a screen image that is up to four times as big as with conventional 35-mm projection, mostly through added height rather than width. The larger picture fills a viewer's field of vision more completely, producing a more captivating effect.

To create the taller picture, filming is done with a specially designed anamorphic lens from Panavision. Anamorphic lenses, which provide different powers of magnification in different directions, have long been used to stretch film images horizontally. But the new lens works vertically; it compresses the picture by about 50% from top to bottom, thereby distorting the image to fit it onto a standard 70-mm film frame. In the theater, an anamorphic projector lens—designed by Isco, a German affiliate of Optical Radiation Corp.—then expands the vertical component of the images without distortion onto the enlarged screen. FuturCinema describes the processed image as "companded," meaning "compressed and expanded."

What's more, FuturVision films are shot and projected at a faster frame rate—30 frames per second (fps), instead of the standard 24. This reduces the familiar effect known as flicker, created when the shutter blacks out the projector while the film is spooled to the next frame. To minimize flicker, both FuturVision and conventional projectors show each film frame twice via a second shutter blade that closes and opens over each frame between spooling, thus doubling the projection rate. FuturVision produces an even steadier picture, projecting what amounts to 60 images per second, versus the standard 48.

In addition to reducing flicker and allowing brighter illumination, a film speed of 30 frames per second would make movies compatible with video, allowing the two media to be merged more easily.

Since FuturVision cuts flicker, a brighter projector lamp can be used for better illumination; at the standard projection rate, a brighter lamp would make flicker too noticeable. Moreover, grain on the film appears less obvious at the higher rate, because the eye is better able to average the random grain patterns on each frame. Finally, rapid-action images appear sharper because the moviemaking camera operates at a faster frame rate. "You have a brighter, more realistic picture with better color saturation," claims Knutsen.

FuturCinema isn't the only one to see the advantages of switching to 30 fps. The feasibility of the faster rate is being studied by a special committee of SMPTE, headed by its film engineering director, Edmund M. DiGiulio of Cinema Products Corp. In addition to improving the visual quality of films, says DiGiulio, the faster rate will make motion pictures more compatible with the standard video sampling rate of 30 images per second, simplifying many filming operations. For example, a film director's "rushes" (the first rough sequences) are often recorded on video, because it costs less. If film and video used the same sampling rates, such video action might be more easily edited into filmed sequences in movies and commercials. This would apply equally to computer-generated special effects, which also use 30-fps sampling. While he does not say when a new film standard may be adopted, DiGiulio is "encouraged by the fact that we are seeing serious interest in this, not only from producers but also from theater owners. They recognize that improvements like this will bring people into the theater."

LOUD AND CLEAR. The more immediate problem facing movie houses, however, is not pictures but sound. Although film sound is usually in multitrack stereo or even more elaborate formats, its ratio of signal to noise (audible electrical interference) is often poor. Now, with digital sound becoming commonplace in homes, "people are going to expect higher-quality sound from movies," says Ronald E. Uhlig, group leader of electronic development of Eastman-Kodak's motion picture and audiovisual products division.

To date, most digital movie sound, like that in the rerelease of Walt Disney's *Fantasia*, has used a separate, nonsynchronized soundtrack: the data are not encoded directly onto the film, as with conventional, analog soundtracks, but on a separate medium such as compact disc. A drawback of this method is that sound may go a few frames out of sync with the screen action, a mismatch that would be unacceptable in films with close-up speaking shots.

A step toward synchronized digital sound was the mid-1986 release of *Home of the Brave*, a concert film by performance artist Laurie Anderson. Although the film uses a separate digital soundtrack played on a specially modified videocassette recorder, audio keeps pace with the film through a time-control code on the sound tape that's constantly compared with a corresponding timing code on a magnetic stripe on the film. Receiving the time data from both film and soundtrack, a FuturVision audio processor speeds up or slows down the tape to

PHIL MATT

Kodak's Ronald Uhlig says audiences accustomed to hi-fi audio in the home expect quality sound from cinemas.

match it precisely with the film. The resulting eight-track digital sound heard in the theater approaches compact disc quality with a dynamic range nearly double that of conventional movie sound, says Knutsen.

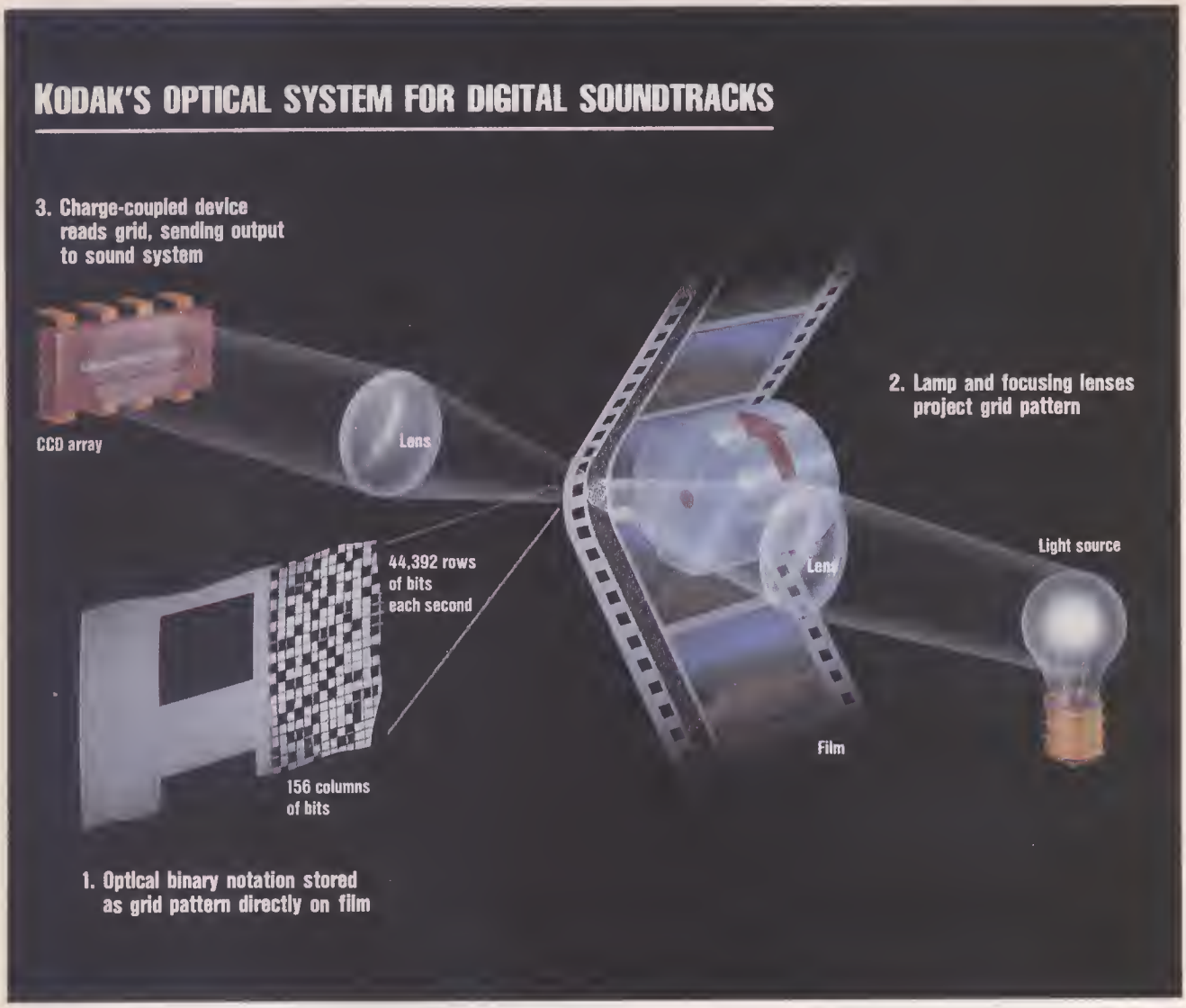
Recording the soundtrack apart from the film poses problems other than synchronization—for instance, film reels and sound tapes may even get separated during shipment to a theater. "The only way you're going to get acceptance is to put the sound on a digital optical track on the film itself," says Tore Nordahl of Mitsubishi's Pro Audio Group. This integrated approach is being taken by both Mitsubishi and Kodak.

Generally, digital recorders sample the sound 48,000 times per second—slightly faster than compact discs' sampling rate of 44.1 kilohertz—and assign a 16-bit digital representation to the sound level of each sample. On an optical soundtrack the binary bits will be represented as either exposed (transparent) or unexposed (opaque) pixels on a 0.2-inch-wide strip between the movie frames and the sprocket holes, where analog soundtracks are currently placed. When the film is shown, a light will project the bit pattern onto an optical reader, which will transmit the data through a digital decoder to the theater's audio system. To record the bits on the film, Kodak is experimenting with a linear array of light-emitting diodes, switched on and off by the audio signal processor as the film spools over the array.

One snag facing digital soundtracks is that recording multiple channels with error correction codes generates so much data that pixels as small as 10 microns ($^1/_{2500}$ inch) across must be used for recording. Tests are under way to determine if movie-film resolution is fine enough to accurately carry such tiny pixels. The small bit size also makes the soundtrack difficult to read during projection. The film may run at an uneven velocity and weave from side to side, especially in older projectors. While this isn't noticeable on the screen, shifts exceeding the 10-micron bit size may introduce errors during reading. "The main technical problem is mechanical stability of the playback equipment," says Mitsubishi's Nordahl. He says most existing projectors would have to be replaced. Mitsubishi is designing projection equipment adapted from its existing professional audio processors and its Westrex-label analog optical sound recorders currently used in film studios.

To solve the film weaving problem, Kodak is experimenting with a linear scanning array of 512 charge-coupled devices, or CCDs (solid-state image sensors), to read the digital soundtrack. Since the array is slightly wider than the sound stripe on the film, it can read the data in spite of lateral shifts. A row of reference bits on the soundtrack permits the signal processor to track the data channels continuously as their position across the CCD array varies.

Other research at Kodak centers on the film. "Our first concern is whether or not film has the resolving power," says Uhlig. "Another concern is whether dirt, scratches, and wear characteristics of the film will interfere." Working with Showscan Film, a supplier of special-venue theater equipment, Kodak has developed an experimental system that reads 6.9 million bits per second. What makes this possible is the wider soundtrack band on Showscan film; it has room for 156 columns of 32-micron bits. Also, Showscan films are projected at 60 fps, permitting some 44,000 rows of bits to pass the opti-



cal reader each second.

The challenge, says Uhlig, is to get sufficient data onto a standard 35-mm film moving at 24 fps. Preliminary tests have shown that Kodak motion picture film is probably capable of the 10-micron resolution demanded by the smaller film format. Also, the company is attempting to reduce the number of soundtrack bits by using a lower sampling rate—32 kHz—and applying data compression techniques to record only eight data bits instead of 16 per sample.

Film-borne digital soundtracks aren't expected to find their way into movie theaters before the end of the present decade. In the shorter term, however, there is much that theaters can do to improve sound quality. For example, only a quarter of American movie theaters are equipped with Dolby stereo noise reduction capability, even though most films have soundtracks recorded in Dolby. More fundamental still, according to Ioan Allen of Dolby Laboratories, is that many theaters have such bad acoustics that better sound quality would go unnoticed. Better noise reduction techniques are feasible, he says, but they would only reduce a film's background noise below the theater's ambient noise level—including the noise from films being played next door in many poorly constructed multiplex theaters. FuturCinema's Knutsen acknowledges that only a fraction of America's current movie theaters will benefit from better audio, but he hopes that demands from moviegoers, as they grow more conditioned to high fidelity through advances in consumer electronics, will force more and more cinema owners to make improvements. □

Digital soundtracks fit handily onto Showscan's wide film, but the trick is to compress the data onto standard 35-mm film while maintaining the resolution necessary for accurate reading.

Hugh Aldersey-Williams, who lives in New York, is a contributing editor of Industrial Design *magazine and a freelance writer covering science and technology.*

For further information see RESOURCES, *p. 66.*

SPECIAL-VENUE THEATERS

BY H. PARIS BURSTYN

While the commercial theater business may lag in new technology, special-venue film is a showcase of advanced cinema concepts. Like FuturVision, the Showscan, Imax, and Omnimax methods all attempt to envelop their viewers in action—both visual and aural. So far the high cost of these techniques has limited them to special theaters at places like science museums and theme parks. However, FuturVision, by attracting customers in both commercial and special-venue markets, may stimulate wider use of the new technologies. Showscan is following a similar strategy, attempting to sell its equipment to both commercial and special markets. Imax and Omnimax remain dedicated to the special-venue market, but they are likely to have a rub-off effect, leading moviegoers to expect more from their main-street cinemas.

LARGER THAN LIFE. Imax Systems developed and supports both Imax and Omnimax movie technologies. Like FuturVision, they rely on giant screens to dominate the audience's viewing field. Imax theaters have flat rectangular screens as large as 95 feet wide and 70 feet high; conventional screens for showing 70-mm films average about 34 by 16 feet. Omnimax movies are viewed in dome-shaped theaters up to 85 feet in diameter, producing a picture that wraps as much as 180° horizontally around the audience, 100° above the horizon, and 22° below it. Omnimax uses special fish-eye lenses for both camera and projector to adapt the image to the curved format.

To project such large images, both Imax and Omnimax use standard 70-mm film that's turned on its side so it moves horizontally rather than vertically through the camera during filming and the projector during screening. This means that individual pictures are oriented from side to side along the film, rather than from bottom to top. Each frame is about 3¾ inches across, or roughly three times the area of regular 70-mm frames.

Although Imax and Omnimax films run at the standard 24 frames per second (fps), they must move about three times as fast, because of their larger frame size. Both the rapid speed and the fact that the film moves horizontally would cause the film to tear if it were transported using the conventional "Geneva" technique, whereby a sprocket reaches through the film perforations and pulls the next frame down to the projection lamp. Instead, Imax Systems uses a "rolling loop" mechanism that snakes the film sideways in gentle waves (similar to a caterpillar's movement) and positions it over fixed register pins that align each frame in front of the projector lamp. A vacuum then secures each frame for projection. Rather than reels, the film is spooled onto four-foot-diameter platters.

Imax equipment is housed in the rear of the theater, but the fish-eye optics of Omnimax demand that the projector be placed near the dome's center. To save auditorium space for seating, film platters, control panel, and sound equipment are located in a control room in the rear. The projector alone intrudes among viewers, typically rising on an elevator-like platform after the theater is full. At Boston's Museum of Science, home of the newest Omnimax theater, the film's rolling loops snake upward two stories to the projector and then undulate the same distance back to the take-up platter.

Brighter projection lamps are needed for the larger images. In Omnimax's dome, this creates a problem of cross-reflectance: light bouncing off one side of the dome may wash out the picture on the other side. To prevent this, the screen portion of the dome is shaded light gray. At Boston's science museum, the screen reflects only 30% of incident light, so that a 15,000-watt lamp is required to get bright enough images.

Omnimax and Imax films use a separate tape for soundtracks, electronically synchronized with the film. Typically, six-track sound is broadcast from separate speaker clusters located above, behind, and on both sides of the screen, as well as on the left and right behind the audience, creating a surround-sound effect. In it's most advanced version at the just-opened Boston theater, the Omnimax sound system has 12 channels, 37 individual amplifiers, and 84 speakers in 12 clusters. The system's 12 subwoofer speakers can reproduce bass at lower-than-audible frequencies—sonics that add to the realism by actually shaking viewers.

The latest Imax Systems enhancement, 3-D films, debuted at Vancouver's Expo 86 last year. Three-dimensional images are created by filming simultaneously with two separate cameras, approximating human binocular vision. To do this, cameras must be close enough together to simulate the distance between human eyes—impossible with Imax's large cameras. Therefore cameramen aim only one camera directly at the scene, with a mir-

A fifteenth of a second of Showscan film (left) projects about 10 times as much visual information as conventional, 35-mm film (above) does in the same amount of time.

William Shaw, Imax vice-president, developed horizontal projection for large images that encircle the audience.

ror beside it reflecting the scene to the second camera. In the theater two projectors simultaneously project the films through lenses polarized at right angles to each other; viewers wear glasses polarized in the same way. The polarized lens on a viewer's right eye blocks out the image from the left projector, and the left lens blocks the right image. Thus each eye sees a separate but almost identical image, juxtaposed to create an illusion of depth.

Although double-projector 3-D has been used in conventional cinema, Imax claims that the technique is more effective in its theaters. First, its use of registration pins and a vacuum to hold each frame in the projector results in very steady images that maintain their relative positions better. Also, the huge Imax and Omnimax screens eliminate the "window" effect, in which 3-D images are cut off when they reach the borders of conventional screens.

AND FASTER YET. Another advanced theater-system vendor, Showscan, differs primarily in its use of a rapid film rate: 60 fps. Developed by Academy Award–winning filmmaker Douglas Trumbull, the concept is based on audience tests that showed that breathing and pulse rates are highest when a film is viewed at 60 fps.

In addition to being larger, the Showscan screen curves slightly around the audience in an effort to fill viewers' peripheral fields of vision. Like the other special-venue formats, Showscan movies are made with specially adapted cameras and shown with modified projection systems. Six-channel audio is recorded on a separate medium, but the company is working with Kodak to develop on-film digital soundtracks.

Theoretically, the advantages of a 30-fps film speed are multiplied by Showscan's 60-fps rate—flicker is lower, resolution is greater, and even more intense illumination can be used, improving color and overall image quality. However, Eric Knutsen, president of competitor FuturCinema, questions the cost-effectiveness of Showscan, noting that each movie requires much more film footage and that theater conversions are more extensive and costly. "From an academic standpoint 60 fps is probably best," he says. "But in a conventional theater, and even some special venues, the economic reality must be considered." Adapting a theater for Showscan can cost up to $150,000 or so, depending on the theater size. FuturCinema says installation of its FuturVision equipment costs only about $10,000, partly because its projector adaptations are not as extensive.

Theater conversions are an important part of both FuturCinema's and Showscan's strategies. In addition to penetrating the special-venue market, the two companies want to attract makers of fea-

Although 3-D movies are nothing new, large screens eliminate the "window" effect, in which the 3-D images are cut off when they reach the borders of conventional theater screens.

ROB LEWINE

One way Showscan gets sharper images is through faster projection, says president Roy Aaron.

ture films. But both competitors suffer from the same dilemma: it's hard to attract filmmakers and producers to a new format if theaters aren't available to show the films, but theaters are reluctant to adopt new formats unless films are available. To encourage theater owners to convert, both companies offer systems that can, with simple setups, run standard motion picture formats and advanced films interchangeably. Knutsen says FuturCinema will even lease its special optics and sound equipment to theaters that would need them only occasionally.

Imax will continue to concentrate on the special-venue arena, where institutions like museums, theme parks, and world's fairs are willing to make the $1–1.5 million investment in construction and equipment. There are now more than 50 such theaters, split almost evenly between Omnimax and Imax formats. The company expects to add about five more by the end of 1987, and to pass the 100-theater mark in five years. Today, 48 films in the Imax library circulate among the theaters.

So far Showscan's penetration has been limited to special-venue theaters, with an installation in Vancouver, B.C., another that opened in May in Niagara Falls, N.Y., and four under construction in New Zealand and Australia. Director of Marketing Cindy Porter says the company expects to have 10 special-venue theaters by year's end. By autumn, says Porter, the company expects to announce plans for a feature film, with production probably beginning in 1988. Likewise, FuturCinema says it will announce plans for a feature film sometime this year. Starting with Loews, its commercial theater network is already being built.

Despite their higher costs and the industry's entrenched technologies, these advanced movie methods may become lifesaving alternatives for theaters squeezed by the consumer electronics boom. To compete, says Jack Valente, president of the Motion Picture Association of America, theaters must "provide an epic viewing experience that can't be duplicated on a VCR." Otherwise, he says, "they're going to be out of business." □

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For further information see **RESOURCES**, *p. 66.*

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Grown in large quantities, genetically altered mammalian cells could become a low-cost source of valuable drugs

HARVESTING THE CELL

Not long ago, genetic engineering was perceived by many as a solution in search of a problem. But recent government approval of several genetically engineered therapeutic proteins, including interferon, human growth hormone, and human insulin, has bolstered the industry's credibility within both the medical and the investment communities. Along with the recognition, however, have come new challenges—most notably, how to produce commercial volumes of the larger and more biologically sophisticated proteins (many of them targeted to human healthcare) that will be needed to drive the industry during the next decade.

About a dozen U.S. companies are betting that the solution lies in large-scale cell culture—various procedures for growing genetically engineered cells in large bioreactors, then harvesting the valuable chemicals produced by the cells. For example, at least one firm is convinced that new vaccines can be derived from its cultures of genetically altered insect cells; others are designing cultures of plant cells to produce pharmaceuticals, cosmetics, and insecticides that are now made by costly chemical processes.

But the most promising new systems are those based on mammalian cells, the only ones with all the genetic "equipment" needed to produce virtually any protein. Although they are extremely delicate and grow very slowly, mammalian cells can perform all the reactions needed to assemble the individual amino acids that make up all proteins, then fold them into the characteristic three-dimensional shapes needed for bioactivity. Mammalian systems are now at work at several locations to produce such proteins as tissue plasminogen activator, or tPA—which dissolves blood clots, and so could become an important new treatment for heart disease—and erythropoietin (EPO), a molecule that regulates the production of red blood cells. The technology is seen as so lucrative that many companies have created new profit centers aimed solely at developing methods of growing mammalian cells for other companies.

The worldwide pharmaceutical industry, which last year enjoyed revenues of about $60 billion, is firmly behind the new production methods. The reason is that about 20% of today's drugs (most of which are made via chemical methods) could ultimately be produced by simpler, more economical biotechnological methods, according to the congressional Office of Technology Assessment in Washington, D.C. As a result, sales of new drugs and diagnostics from genetically engineered cell-culture systems could top $10 billion by 1995.

BY RICKI LEWIS

NEW CHALLENGES. Biotechnology's first milestones—the commercialization of genetically engineered interferon and other proteins—ushered in a host of new technological challenges. Those early offerings were relatively uncomplicated molecules, and so could be made efficiently in simple single-cell bacteria and yeasts. In these processes, a gene that regulates, or "codes for," the production of the protein is chemically isolated from a higher organism that normally makes the protein and transferred to a bacterium (which normally doesn't). If the transfer is successful, the microbe's descendants regard the foreign gene as their own and begin to manufacture the protein.

But tPA, EPO, and other upcoming products tend to be large, complex molecules and combinations of molecules. Many of them are glycoproteins (combinations of a protein and a sugar molecule), and while bacteria can often produce the protein portion of the molecule, the sugar must be added in a separate step. In fact, given its limited repertoire of protein-assembling genes—typically only a few thousand, versus as many as 100,000 in mammalian cells—a bacterium can no more "build" a large hormone or enzyme than one can build an automobile from scratch in a basement workshop.

Thus there is a need for more complex cells, especially those derived from mammals. Not only can such cells attach the all-important sugar to the protein portion of the molecule (a reaction called glycosylation), but they often secrete the desired product into the surrounding medium for easy collection; by contrast, bacterial cells must usually be mechanically or chemically broken up in order for their products to be harvested. Since mammalian cells needn't be destroyed, they are a readily renewable source of biochemicals.

But the advent of new cell culture systems by no means implies the scrapping of older, simpler methods. Bacteria are quite efficient for producing interferon and other nonglycosylated proteins, says Phillip Whitcome, director of strategic planning at Amgen; the trick is to match the desired biochemical to the highest-yield, lowest-cost cell system. As a result, most companies are now experimenting with cultures based on several cell types. At Amgen, says Whitcome, researchers are using yeast cells for fairly simple products such as the hepatitis B vaccine

ED KASHI

Bio-Response's Fouron displays one of the company's bioreactors, used to grow protein-producing mammalian cells.

and mammalian cells for the more complex EPO.

FRAGILE CELLS. Although mammalian cells can in theory be genetically engineered to produce any protein, they are also notoriously difficult to work with. One problem is that the cells of most higher animals are extremely delicate and thus easily damaged by the propellers of conventional bacterial fermenters. "Just rubbing against a mammalian cell is enough to break its membrane," says Yves Fouron, vice-president of business development at Bio-Response. "The cell simply dies."

Another obstacle is that unlike bacteria (which divide two or three times an hour), mammalian cells grow very slowly, dividing to form new cells every 18–48 hours; it is therefore difficult to reach the high cell densities—about 10 billion per cubic centimeter—that are typical of living systems and that are required for optimal protein production. And whereas a bacterium is an independent, free-living organism, every mammalian cell is just one part of a much larger organism; it demands a steady stream of nutrients, hormones, and other essential molecules that are normally provided by other cells in the system—requirements that are still not fully understood by cell culturists. "We're much better at engineering animal cells than we are at scaling up the cultures," says Joseph Feder, director of Monsanto's cell culture lab.

Yet another problem is the striking diversity among mammalian cells, even among various cells taken from a single animal. While that diversity is vital to the living organism, it presents cell culturists with an enormous number of variables. For example, says Feder, different cells glycosylate differently by attaching different sugars to the protein. And cells that have been genetically altered to produce a new protein don't necessarily act the same as normal cells.

Nevertheless, mammalian cell culture is the center of attention at many companies, simply because of the large body of products they can generate. For example, clot-dissolving tPA is now being produced in a culture of mouse cells at Integrated Genetics and other companies; the product is currently in clinical trials, with eventual worldwide sales expected to top $500 million a year. And the projected annual U.S. market for EPO (also being produced in mouse cells at Integrated Genetics) is $100 million. EPO could help replace red blood cells in kidney dialysis patients and those suffering from anemia or blood cancers. The protein might also be used to help restore blood cells in the growing number of patients who set aside several pints of their own blood in the months before elective surgery, thus avoiding the possibility of receiving contaminated blood. Development of the drug is being funded by Behringwerke AG, a subsidiary of West Germany's Hoechst, in exchange for worldwide marketing rights.

Alternatives To Mammalian Cells

Although mammals provide the most versatile cells for producing genetically engineered molecules, several companies think that insect and plant cells could also serve as mini-factories for new pharmaceuticals, cosmetics, and other products.

For example, four-year-old MicroGeneSys hopes to develop a hepatitis B vaccine via cell cultures from moths called armyworms. While other companies are reportedly exploring insect-cell systems as well, says marketing director Mark Cochran, MicroGeneSys is so far the only one focusing on them exclusively.

The company has identified a piece of viral DNA, called a promoter sequence, that boosts the protein output of genes attached to it. MicroGeneSys researchers hope to use this sequence to produce large amounts of viral surface antigen—a harmless protein found on the surface of the hepatitis B virus. When injected into humans, the antigen acts as a vaccine by arming the immune system against the whole hepatitis virus.

To make the required large quantities of the surface antigen, the researchers first insert the gene that codes for the surface antigen into the virus that contains the promoter sequence, then infect the armyworm cells with this altered virus. Prompted by the promoter sequence, the cells are expected to produce large volumes of antigen, which will be extracted from the culture for use in the vaccine.

Meanwhile, cultures of specially treated plant cells might serve as sources of new or existing plant-derived chemicals (including drugs, flavorings, and pesticides), which now add up to an $8-billion-a-year market in the United States. Because conventional methods for producing these chemicals are well developed, and because little is known about the hormonal and nutritional requirements of plant-cell culture, corporate interest in this approach is still somewhat limited; most companies either synthesize a product by conventional chemistry or chemically extract it from whole plants, according to Richard Stevenson, assistant director of exploratory research at Hoffmann-La Roche.

Extraction of the products from a whole plant is often difficult, however; in nature they are made only in certain cells of certain plants at certain times in development and so cannot simply be produced on demand. Moreover, many of the chemicals are present in trace amounts in the plant, requiring tons of whole plants to obtain a few pounds of the desired chemical.

Plant-cell culture is thus a potentially efficient and lucrative alternative to conventional methods, since many of the products sell for thousands of dollars a pound. For example, an alkaloid extracted from plants of the genus *Catharanthus* is now being tested for antitumor properties. (*Catharanthus* is also the source of the anticancer drug vincristine.) Priced at $20,000 a gram, the extract could in theory be made up to 20 times more efficiently from culture than from the whole plant, according to researcher J. P. Kutney at the University of British Columbia (Vancouver).

Nevertheless, says William Bollinger, vice-president for strategic development at NPI, a plant genetics company, only a dozen or so plant products are now considered profitable enough—that is, priced at $500 or more per kilogram—to justify cell culture over synthesis or extraction. NPI is studying a natural plant insecticide, called azadirachtin, for growth in plant-cell culture.

In Japan, meanwhile, Mitsui Corp. is marketing a plant cell–cultured chemical called shikonin, which sells for several thousand dollars a pound and is widely used in Japan as a bactericide and astringent. However, the plant from which

Another potential growth area for these systems is the culture of the delicate hybridoma cells that manufacture monoclonal antibodies, proteins that are widely used in medical diagnostics and treatment. The hybridomas—immune-system cells that have been fused with cancer cells—have traditionally been grown in the body cavities of mice. However, some 20,000 mice are needed to produce just two pounds of these antibodies; the same output can readily be achieved in a single bioreactor using mammalian cell culture.

A NEW INDUSTRY. The infant art/science of growing mammalian cells has in effect launched a new mini-industry within biotechnology: companies that hope to stake out marketing niches with proprietary bioreactors for growing cells developed by other companies. The result is a wide assortment of new cell culture systems, each tuned to the particular biological needs of different mammalian cells.

For example, some cells grow to densities of about 2 million per cc while suspended in a circulating mixture of nutrients and dissolved gases. One system developed for such cells is the so-called airlift fermenter developed by Celltech. Although the fermenter resembles conventional propeller-churned bioreactors in many respects, the cells and nutrients are stirred by a steady, gentle infusion of gas bubbles. The fermenter is now being used by Celltech to produce a variety of proteins from clients' cell lines; the company is also licensing the design (under the name Cytair) to customers who prefer to maintain their own production facilities.

But most mammalian cells are "anchorage-dependent"; that is, they function only when they are attached to a support or substrate, much as they are in a living body. Thus they are often cultured while attached to inert beads or embedded in gels. Cells can also be grown for long periods of time, and at very high densities, in the narrow spaces between hollow fibers that are bundled into glass or plastic cylinders. The technique is now being used at Bio-Response and Amicon (Danvers, Mass.), as well as in a joint venture between Endotronics and Summa Medical Corporation.

A variety of cell types grow to high densities in Endotronics' hollow-fiber system, called Acusyst, which mimics the body's circulatory system. Acusyst typically comprises six 20-milliliter bioreactors in tandem, each containing 320 looped hollow fibers; the cells grow outside the fibers, and secrete into the tiny pores of the fibers, from whence the products are collected.

One problem with very large hollow-fiber systems, however, is the formation of lethal "microenvironments" in the spaces around the fibers—stagnant regions that are often characterized by uneven nutrient distribution or by the buildup of waste products. These microenvironments present cell culturists with a trade-off, since the degree of stagnation is generally proportional to the number of cells.

Endotronics says it prevents the problem with a media circulation system in which a computer controls pressure differences between the hollow-fiber chamber and an external chamber. The company claims that its 100-ml bioreactor supports cell densities of at least 10 million per cc. Bio-Response controls microenvironment development for certain types of cells by using small reactors

shikonin is extracted is very rare in Japan (a factor that was added to the chemical's high price to justify Mitsui's special culture-development program). The same criteria may ultimately lead to cell culture production of several other costly chemicals, including steroid hormone precursors, anticancer agents, and essential oils such as rose oil, which sells for about $1000 a pound.

Perhaps the most unusual development in cell culture technology, however, will be the use of "transgenic" animals—those that arise from a fertilized egg containing foreign genes that become active (are "expressed") later in the animal's life. If the added genes can be hooked to other genes that trigger their expression in certain body fluids, the animals would essentially become walking cell cultures that would be far less costly (and require much less maintenance) than today's mammalian cultures.

The injection of foreign genes into fertilized eggs—and their expression in the mature animal—has already succeeded in mice, rabbits, pigs, and sheep, and is now being studied in cattle. In the latter case, it may eventually be possible to inject a gene for a therapeutic protein (such as human insulin) into a fertilized cow egg, attaching it to a promoter sequence that would trigger its expression in milk; the insulin would later be recovered from the milk by conventional separation methods.

Despite its almost science-fiction aura, the method is now being developed by several companies. "We've shown that therapeutic proteins can be produced in transgenic mice," says Patrick Connoy, marketing director at Integrated Genetics, "and we hope to submit products from these animals to the FDA within five years." The company has identified several candidate molecules for transgenic production, he says, including tissue plasminogen activator, a protein that may eventually be used to treat heart attacks in progress by dissolving blood clots in the coronary arteries.

WM. FLOYD HOLDMAN

Plant cells may one day be engineered to produce a variety of new drugs, says NPI's Bollinger (above). But for now, chemical synthesis is usually cheaper.

In this virus-infected insect cell, viral proteins appear as crystals. Other valuable proteins could also be grown in the cell by altering viral genes.

maintained at higher cell densities (about 50 million per cc); large volumes of protein are obtained by operating several reactors in tandem. A single one of the company's 300-ml hollow-fiber units produces up to a gram of antibody a day, according to Fouron, who adds that "millions of diagnostic test kits can be made from just a few grams of antibody."

The type of fiber used is geared to the cell type: cells that prefer to grow in suspension do well with fibers of cellulose acetate, whereas anchorage-dependent cells fare better with polypropylene fibers. Endotronics has a joint venture with Celanese to explore new polymer materials for fibers, and with Summa Medical to improve protein production from the Acusyst line.

Bio-Response has developed another approach to growing certain types of anchorage-dependent cells—beds of immobile glass beads that, like hollow fibers, provide a gentle growth environment. "The only agitation is in the fluid, with nutrients percolating through the reactor," says Fouron. The company is now using the glass-bed bioreactor to produce a proprietary human hormone in cells derived from human tissue.

In a variation on the bead theme, Damon Biotech grows mammalian cells that have been encapsulated in microscopic globules of a chemical called alginate. The company has used the system (dubbed Encapcel) for several years to grow monoclonal antibodies for Hoffmann-La Roche, which uses them to purify interferon produced by genetically engineered bacteria. And at Verax, antibodies are produced in 10-liter bioreactors containing millions of microscopic collagen-based beads, which resemble tiny sponges. (The company also maintains several 800-liter bioreactors for large-volume antibody production.) Bathed in a steady flow of nutrients, the beads are used to grow both suspension-type hybridomas, which float within the beads' billions of tiny "caverns," and anchorage-dependent hybridomas, which attach themselves to the various surfaces.

PROPRIETARY REACTORS. Although some mammalian cells grow well under relatively uncomplicated conditions, most function only in an extremely complex environment in which such variables as hormones, gases, nutrients, waste products, and growth additives are maintained in careful balance. Moreover, conditions that foster the growth of one type of cell (those that tend to clump together, for example) may be fatal to others (say, those that prefer plenty of elbow room). And while small, simple culture systems are often satisfactory for short-term batch runs (in which only a small amount of protein is wanted), the trend in most companies is toward more or less permanent systems that turn out large volumes of a single product over a period of months or years.

As a result, several companies have designed proprietary bioreactors that they claim are easily tuned to grow large volumes of virtually any type of cell over long periods of time. Although each design boasts one or more unique features, all of them strive for the same goal: to replicate the conditions of the living body by monitoring the cell's environment for optimal densities and by keeping the cells well perfused (constantly bathed in liquids that supply nutrients and carry away wastes).

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BIOTECH FIRMS CULTIVATE CELL MARKET

Biotechnology companies are increasingly turning to specialized firms for the growth of large quantities of genetically altered cells that are needed to commercially produce monoclonal antibodies (MAbs) and other valuable proteins. The bioreactors most frequently used in such processing are adapted for work with mammalian cells; although such cells can be difficult to grow in volume, they are particularly well suited for making large, complex, biologically active proteins.

Invitron (St. Louis) and Celltech (Slough, England) run the largest mammalian cell-culturing operations in the world. Other companies with large-scale growth systems include Damon Biotech (Needham Heights, Mass.), Endotronics (Coon Rapids, Minn.), and Integrated Genetics (Framingham, Mass.). Several established firms, including Abbott Laboratories (Abbott Park, Ill.), Du Pont (Wilmington, Del.), Eli Lilly (Indianapolis), and Johnson & Johnson (New Brunswick, N.J.), are exploring the possibility of becoming self-sufficient in cell culture.

During the next five years, the number of pharmaceutical products manufactured this way is expected to grow from fewer than a dozen to more than 80, says Linda Miller, biotech analyst at PaineWebber (New York). Estimated revenues from just the production of MAbs, the principal high-value protein now being made by cell-culture companies, were $15 million last year and should reach $300 million by 1991, according to Viren Mehta, VP of healthcare research at Wood Mackenzie (New York). Other cell-culture products include blood clot–dissolving tissue plasminogen activator (tPA), which could achieve $500 million in sales within a few years, and erythropoietin (EPO)—a hormone for treating anemia—which could be worth $225 million by 1990, according to David Webber, editor of *Biotech Investor*, a publication of Casdin Associates (New York).

There is a continuing debate within the industry about which of the various processes will provide the efficiencies needed for mass production of cells. Invitron touts its 1.3-million-liter modular perfusion system, which siphons off and harvests cells once their density has reached certain levels. The company says that this technology, used in conjunction with high-capacity filters and extremely pure water, eliminates the need for antibiotics (which stem bacterial infections within producer mammalian cells), reduces the amount of nutrient broth that is used, and simplifies purification procedures to improve product yields. These characteristics could enhance the company's competitiveness as federal regulators scrutinize products from different cell-culture facilities for possible contamination by antibiotics, stray protein or other biochemical materials, and viruses.

But competing culture processes may offer other benefits. Britain's Celltech, for instance, claims that its batch-type systems have a longer track record than competitive technologies in producing high volumes of monoclonal antibodies at a relatively low cost. And Damon Biotech uses a proprietary cell encapsulation technology to achieve high-density growth, scaling back the need for the sort of high-volume growth chambers and mammoth facilities required by other processes.

Current and potential patent disputes are also likely to affect the biotech industry. For instance, Genentech and Wellcome Foundation are in a patent infringement dispute over tPA in Great Britain, Becton Dickinson has agreed to pay Johnson & Johnson royalties in settling a MAb diagnostic product suit, and Amgen and Genetics Institute face a possible clash over patent claims for EPO. "If you're a cell-culture company, and the product you're making for a customer is blocked by someone else's patent, you're out of luck," says *Biotech Investor*'s Webber. On the other hand, David Gration, commercial director of Celltech, feels that firms like his can play a winning hand, whatever the outcome of such litigation. "If we can make products at low cost, whoever wins the patent will still have to come to us," he says. □ ***—Jeffrey L. Fox***

MARK CORSON

"Mammalian cells can be difficult to work with, but they are needed for producing certain high-value, complex proteins that dissolve blood clots or stimulate other desired results in humans."
Gary Snable, Executive VP for marketing
Invitron

"A company's capacity to undertake large-scale cell culturing does not by itself ensure market leadership. The firm must also possess the skills and experience to purify end products in a cost-effective manner."
Viren Mehta, VP of healthcare research
Wood Mackenzie

One example is Bio-Response's Mass Culturing Techniques, or MCT—in effect, a family of reactors, each based on a single fundamental design, for producing specific biochemicals from clients' cells. Fouron claims that the reactors reach the very high cell densities (at least 1000 times those of a conventional fermenter) needed for optimal cell growth. While Fouron declines to identify Bio-Response's corporate customers, he notes that MCT has been used to produce hormones, enzymes, cytokines and lymphokines (both immune-system biochemicals), and monoclonal antibodies.

Every MCT bioreactor consists of a cell growth chamber sandwiched between two semipermeable membranes (which in some cases consist of hollow fibers). The "cell-exclusion" membrane has holes that are large enough for the product to leak out for collection, but small enough to keep the cells in the chamber. On the other side, the "product-exclusion" membrane has even smaller pores, which allow nutrients to flow into the chamber and wastes to flow out in order to be discarded through a constantly recycled flow of media.

Fluids and nutrients in the reactor are transported much as in the human circulatory system, making the cells "feel at home"; in the newest MCT designs, cell density approaches a billion per cc. And because MCT provides for the continuous flow of materials and waste products, says Fouron, the culture "can function for virtually unlimited periods of time." In other types of reactors, by contrast, production is often limited as cells grow to a maximal density, then die from overcrowding.

Meanwhile, two other new reactor designs are being promoted by Invitron: one that grows cells to high densities and one that maintains them in a static, low-growth condition that is often conducive to high protein output. (Although most companies recognize the importance of this "steady state" in cell culture, Invitron and Bio-Response appear to be the only ones that have designed systems specifically for this purpose.) The three-year-old company, a spinoff of nearby Monsanto, aims to commercialize many of the cell culture technologies developed as part of Monsanto's life sciences R&D.

Invitron's large-scale perfusion culture system is used for both suspension and anchorage-dependent cells, says Feder; the latter type of cells are accommodated by adding inert "microcarriers" to the growth vessel. When the density reaches a predetermined level, the cells and the products are automatically removed to a harvesting vessel. The proteins are recovered by special filtration and separation methods, and the cells are returned to the bioreactor for continued growth and protein production. This cell recycling maintains a fairly constant density, according to Feder—a provision that prevents delicate cells from being literally crushed to death and reduces the amount of costly nutrients needed for cell maintenance. The perfusion reactor is now being used to grow various mammalian cells for producing future Monsanto products, such as tPA, EPO, and bovine somatostatin (a hormone that boosts milk production in cattle).

But high rates of cell growth are not always desired; in fact, many mammalian cells secrete their proteins while in a steady, nondividing state. Invitron's static maintenance reactor is designed to prevent cell division for long periods of time by maintaining the cells at very high densities in a proprietary matrix material that simply provides no room for cell division. The result is not only increased protein output but also a lower chance of cell mutation (genetic changes are not uncommon during division and may alter the secreted protein). Bio-Response's MCT reactors maintain the cells in a steady state by altering the composition of the nutrients.

Mammalian cell culture clearly is still in a very early stage of development, and it would be foolhardy to predict the ultimate success or failure of any single method. Given the huge diversity of mammalian cells, each with its own biological peculiarities, it is likely that a variety of culture methods will continue to evolve, each meeting a particular need of a particular type of cell. In fact, it's possible that one or more entirely new technologies (natural or synthetic "growth factors," for example) will be introduced for growing and maintaining these fragile and exquisitely complex living systems.

But the precise form of tomorrow's cell culture systems is less important than the evolution process itself. "There's no question that we can supply the marketplace with these products," says Monsanto's Feder. "But that doesn't mean we're doing it as efficiently as we can." Only through steady, controlled change (and perhaps now and then a genuine breakthrough) can the young biotech industry continue to provide the important new molecules that will fuel its growth during the next decade—and do so economically and consistently in an increasingly competitive marketplace. □

Ricki Lewis, who has a PhD in genetics from Indiana University, teaches at the State University of New York/Albany. She is a frequent contributor to HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p. 66.*

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REVOLUTION IN TOYLAND

Parents take warning: Stuffed animals have started talking back, toy robots are taking orders from the TV set, and your kids may be packing ray guns

BY HERB BRODY

The video game boom of the early '80s brought hordes of products aimed at satisfying the seemingly primal urge to control colored blips scooting around a TV screen. That fad died of malnourishment; game companies' inability to sustain an outpouring of original games meant that after a while every new video game seemed like another variation on Pac-Man or Space Invaders, and no amount of graphic refinement or souped-up sound effects could hold people's interest. Video game cartridges piled up in the clearance bins of discount stores.

Now those barons of fun and games are at it again. The past 18 months have brought an army of electronic dolls, teddy bears, action figures (the industry's euphemism for boys' dolls), light-beam guns, and other paraphernalia. These high tech toys are marching under the common banner of "interactivity," loosely defined as anything that produces a technological response to a child's talk or action. "We ask ourselves: what would we have just died for when we were kids?" says Paul Rago, vice-president for marketing at Worlds of Wonder, a leader in high tech playthings. And children are not the only ones frolicking with these gadgets. Much of the appeal of new games like Lazer Tag and Photon, in which the players zap each other with light beams, has been to college students and young adults.

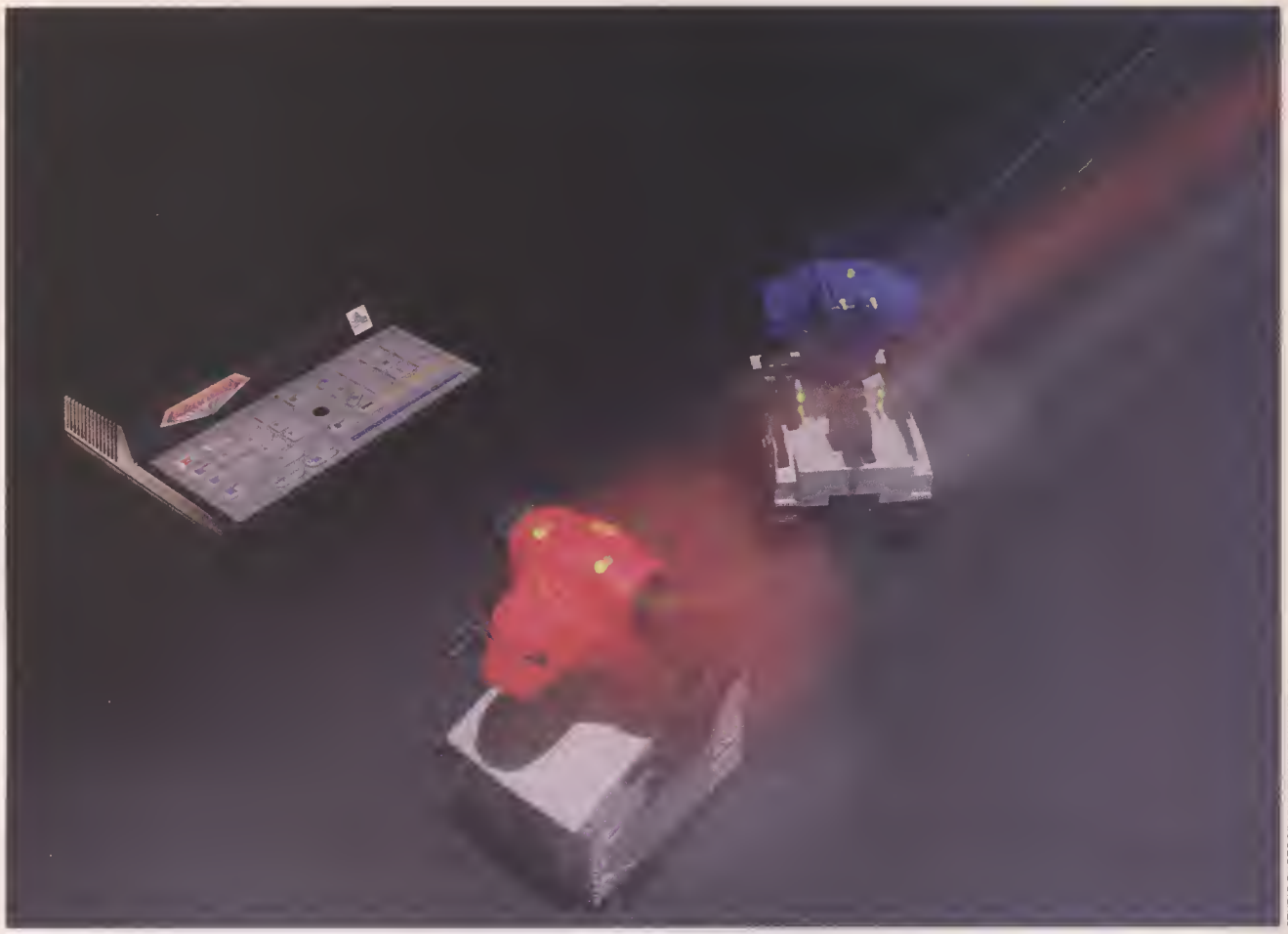
Worlds of Wonder launched the latest brigade of toys in 1985 with a talking bear—Teddy Ruxpin—that features synchronized facial motion. Teddy Ruxpin (typical retail: $50) is basically a fur-covered tape recorder, with motors that open and close the mouth and move the eyes around. It plays special cassettes, with the motor-control signals encoded digitally on one of the stereo channels and the audio carried on the other channel, according to Larry Larsen, a co-owner of Alchemy II, from which Worlds of Wonder licenses the product.

Its dependence on an audio tape severely limits Ruxpin's capabilities; the bear tells its tales beginning to end no matter how the child responds. Ruxpin's successors, developed by Worlds of Wonder and other companies, take the new toy category of "animatronics" beyond such simple, linear storytelling.

Baby Talk ($65–$75), introduced last year by Lewis Galoob Toys, is billed as the first chip-based interactive doll. Stick a bottle in her mouth and she sucks it—then pauses to say something like "More, Mommy," or "Mommy, feed me," moving her lips in sync. About 20 other phrases are cooed at vaguely appropriate times. Pick her up and she'll say "I love you" or "hug me." Lay her on her tummy and she'll ask to be turned over. The doll is programmed with typical behavior patterns, too. After eating, for example, she sometimes—but not always—announces that she is tired and wants to sleep.

Noting the success of Teddy Ruxpin, Galoob this year is turning Baby Talk into a storyteller as well. The doll will plug into a videocassette recorder, via an adapter unit ($50–$55). When Baby Talk tapes are played, the doll will talk and sing along with the characters on the screen. When used this way, there's no interactivity; the child just watches, with the doll serving essentially as an extension of the TV screen.

Other new dolls incorporate speech recognition chips so they can listen as well as talk. Jill ($149), from Playmates, stops every 30 seconds or so during the telling of a story to ask the child what ought to happen next. For example, should the hero enter a haunted house through the front



STUDIO PHOTOGRAPHY BY MIKE MALYSZKO

Television spills out onto the living-room floor: Axlon's Techforce vehicles can take their marching orders from signals imbedded in the broadcast of a new cartoon show.

door, back door, or window? The story then proceeds in one of three ways, depending on the answer. (If the child delivers an unrecognizable reply or says nothing, Jill continues along a default track.)

The tape cassettes containing Jill's stories are unique. They are about the size of a credit card and a quarter inch thick. To lessen the chance of damage, the exposed length of tape is about half that of a conventional audio tape. Once inserted into the doll, the tape unloads its contents—audio, instructions for synchronously moving Jill's eyes and 13 free joints, and codes for recognizing 150 words—into a memory chip in the doll. Thus branching to different outcomes requires only an electronic change of course, not spooling through a few feet of tape. Although a tape holds 45 minutes of sound to cover all the possible outcomes, the actual story lasts about 15 minutes.

While Jill is one of a handful of new dolls that can claim true voice recognition, several others that have come out in the last year or two offer a more limited capability—responding to the voice without actually being able to distinguish what words were spoken. For example, A.G. Bear ($20–$40), from Axlon, emits low electronic grunts with roughly the same rises and dips in pitch as the last three seconds of human speech. Since it utters no intelligible words, one might say that A.G. bearly talks. To make the bear more conversational, Axlon programmed A.G. to recognize a questioning tone of voice by the rise in pitch at the end; rather than mimicking that intonation (answering a question with a question), A.G. responds with a "statement"—a monosyllable (yes/no) or a downward vocal inflection. Because the bear's growls can mean pretty much whatever the child wants them to, A.G. leaves more room for fantasy play than most of the other talking dolls and animals.

A doll incorporating both voice responsiveness and speech generation can give the illusion of understanding what is being said. Dozzzy ($60), from Galoob, chats and tells bedtime stories, pausing occasionally to ask questions. The doll might ask: "Did you brush your teeth?" and then wait for an answer. No matter what the reply, however, Dozzzy comes back with an ambiguous response, such as "My mouth always feels so clean after I brush my teeth." Or during "Hansel and Gretel," Dozzzy might say something like: "I'd be afraid to go into such a dark house, wouldn't you?" The doll waits for an answer—any answer—and then continues on with the story. Since the tales are stored on a standard audio cassette, not loaded into an electronic memory, the outcome is always the same. (If there's no response at all, Dozzzy assumes the child has fallen asleep, and shuts itself off.)

With more sophisticated speech recognition, a doll can carry on vaguely humanlike interaction. Julie ($100), due out this fall from Worlds of Wonder, can converse on a number of topics, selected either by the doll or by the child. As the child talks, Julie listens for key words that are part of her vocabulary. If the doll hears "hungry," for example, she will respond with one of the several food-oriented sentences stored on a speech synthesis chip. Julie may then throw the ball back into the child's court with a question such as "Do you like to cook?" then head off into that subject if the answer is yes.

Julie will be equipped with a variety of sensors, so that topics of conversation can come from changes in the environment. A

photodetector tells roughly whether it's light or dark; upon entering bright sunshine from the indoors, Julie might say that she needs to put on sunglasses. And readings from a built-in thermometer prompt her to say things such as "It's cold in here—I need a sweater." Motion sensors tell Julie when she's being picked up: "Where are we going?" she might ask. Julie is capable of five or ten different responses for each situation or input.

Other sensors let Julie "read"; touch her fingertip to one of the pictures in a special book and she will announce what it is. The information is picked up by metal contacts in her fingertips, which gauge the electrical resistance of the page surface (different pictures are coated with inks of different resistance). To open up additional subject areas, you can plug in a new memory cartridge; each 64-kilobyte cartridge, about the size of a credit card, contains material on new topics, such as going to a slumber party, or the ABCs.

Julie must first be "trained" to recognize the voice of the individual child. That way, the voice-recognizing circuitry need not cope with the wide variability in different people's voices, so Julie can understand a larger number of words than would otherwise be possible with the same amount of processing power.

Two electronic pets from Phonetica One balance this trade-off differently: they can recognize any person's voice without training but can understand only a few phrases. The animals—a koala and a charpay dog—amble forward at the command "come here," and then obey commands to "stop" and "turn around." Switching an animal to "security mode" activates an ultrasonic sensor; you have one minute to leave, after which time any motion in the vicinity will cause the animal to shriek and beep. When not earning their keep as watchdogs (or watchmarsupials), the electronic pets can elicit a few giggles with song-and-dance acts; the koala rocks back and forth while playing a computer-synthesized version of "Waltzing Matilda." At $225, these furry robots will likely show up as often at adult gatherings as in nurseries. (The HIGH TECHNOLOGY staff, for instance, spent the better part of a morning subjecting the animals to rigorous and highly scientific tests.)

Critters like Phonetica's, which use sound synthesis chips, tend to be cuddlier than toys that rely on bulky tape recorders. Some of the new products, however, will exploit the advantages of tape—high sound quality and long play—without giving up huggability. In Worlds of Wonder's Muppet Babies, story tapes will be played in a "magic trunk," which contains a cassette recorder linked to a radio-frequency transmitter. The dolls (Baby Kermit, Baby Miss Piggy, et al.) will be equipped with electronics to receive the transmissions and translate them into signals to move the eyes and mouths when their character is speaking on the tape. Thus each Muppet appears to be telling its own part of the story.

Ideal, a stalwart of the traditional toy industry, is introducing a similar product, also using Sesame Street characters. Ideal embeds the tape recorder in a Big Bird replica, and control signals travel to satellite characters via an umbilical cable; Cookie Monster rolls his eyes and moves his mouth, and Oscar the Grouch pops in and out of his trash can.

Carrying toy interactivity to its logical extreme, Coleco Industries is endowing a new line of Cabbage Patch Kids with the ability to converse with each other; participation by the child is optional. Once powered up, a Talking Kid ($100) begins emitting radio waves that can be detected by any other Kid within about 25 feet. The Kids then greet each other with radio signals—and with audible speech for the benefit of the humans who are listening in.

Once contact is established, the dolls converse on a variety of subjects. In keeping with the uniqueness theme that Coleco has used to market the pre-verbal Cabbage Patchers, each doll has a different-sounding voice; all are digitized from recordings of real four-year-old girls, says vice-president Barbara Wruck. And each doll has its own "personality." If the topic is ice cream, for example, one might say that she likes chocolate and another vanilla. The child's role in the conversation is that of instigator. Picking up a Kid stimulates motion sensors that might prompt a question such as "Where are we going?" Another Kid nearby might then say, "Can I come too?" According to Wruck, "a couple of dozen" different utterances are possible for any given stimulus.

Most animatronic toys marketed so far are ends unto themselves. But the technology can be used to augment more traditional play. Galoob expects that its hottest new product this year will be a character called Mr. Game Show ($100)—a 16-inch-tall figure with lacquered hair and big white teeth, who acts as emcee for up to four players in games similar to those on popular TV shows such as *Wheel of Fortune*. Mr. Game Show has a 700-word synthetic-speech vocabulary, with which he

Zap! You're dead: Photon warriors play capture the flag with lightguns in a video game come to life.

SHELLY KATZ/BLACK STAR

tells players the rules, asks them questions, and in general keeps the game moving, just like the real game show hosts on television. And like his TV models, Mr. Game Show delivers a steady stream of quips and good-natured putdowns. (To a losing player: "You get $200—heck, I spend more than that every week on hair spray.")

In addition to such window-dressing roles, Mr. Game Show can also participate in some games. In a variation on Simon says, for example, the animated host calls out a set of initials, a number, or a color. The player so designated is supposed to punch his button—but only if Mr. Game Show has moved his mouth while issuing the call.

The main purpose of Mr. Game Show, concedes Galoob R&D director Rand Siegfried, is to add interest to activities that would otherwise seem too dull to spend much time with. "Nobody plays 'hangman' once they stop going to study hall, because there are better things to do, like talk," he says. Galoob is counting on the appeal of Mr. Game Show to make even such simpleminded pastimes a fun family activity, says Siegfried.

One of the most popular toys of the last year turns the shoot-'em-up thrill of a video game into physical sport. In Lazer Tag, from Worlds of Wonder, players don light-sensitive vests and belts, and carry infrared-emitting guns. Teams score points by tagging opposing players with light beams. The beams are modulated with a characteristic "signature" so that the sensors can distinguish them from the far more intense infrared coming from the sun. Although Lazer Tag's technology resembles that used by the Army to conduct training maneuvers, Worlds of Wonder tries to play down the military implications. "Unfortunately," says marketing VP Rago, "a tube with a handle is a highly charged image." (Just how provocative toy guns can be was made tragically clear this spring in California. A police officer who believed he was facing an armed prowler shot and killed a young man playing Lazer Tag.)

The Star Wars allure of zapping your opponent with a ray gun does not end with childhood. Last fall, Worlds of Wonder sponsored a college Lazer Tag tournament, won by Long Beach State. This year, according to Rago, several schools will have intramural Lazer Tag programs. And a similar Buck Rogers–style game draws a mix of ages to 18 futuristic amusement centers around the country, owned by or franchised from Photon Entertainment. Participants wearing 14 pounds of space-war gear pay about $3 for 6½ minutes of high tech capture-the-flag in a dimly lit 10,000-square-foot room. (Some franchises lower the rates for an early-evening "Zappy Hour.") The object is to find your way through the maze-like setup to the opponent's base. A central computer monitors the action, tallying up individual and team scores.

The first Photon center opened in Dallas in 1984; by year's end, 25–30 will be in operation, according to marketing director Mary Rygiel. She says that a typical center grosses about $1 million a year, and that 30% of the clientele are age 25 or older. The advent of Lazer Tag has helped business, she says; buyers of the toy-store versions come to the Photon centers to hone their skills in a controlled environment. And Photon Entertainment has itself entered the home market; a licensee, LJN Toys, offers a Photon setup similar to Lazer Tag.

Furry robots from Phonetica One come when called and howl at intruders.

Worlds of Wonder CEO Donald Kingsborough (left) and VP Paul Rago cuddle up with Teddy Ruxpin, Julie, and other talking toys.

ROBERT HOLMGREN

The toy industry has long relied on television to promote its wares—to the point where some cartoon shows amount to half-hour commercials for a particular product. This fall, however, the already cozy relationship between toys and TV will reach a new level of intimacy. Two companies—Mattel and Axlon—are marketing toys that will serve as peripherals to certain shows.

Mattel's approach to interactivity resembles that of a traditional video game. For about five minutes during a half-hour program that mixes live action with computer animation, the child will earn points by firing an airplane-shaped gun ($35) at bad guys on the screen from a distance of up to 10 feet. Meanwhile, the TV will somehow fire back, taking away points. (Mattel is disclosing no information on how signals are transmitted from the television during the show, called *Captain Power and the Soldiers of the Future.*) If the player loses all his points, the airplane's cockpit will eject. And when the hero of the show—Captain Power—gives a battle cry, an "energizer" accessory will send a beam of light through the child's Captain Power doll. While activated, the energizer will allow points to be scored for and against other players within range.

Although early publicity portrayed the product as relying on the show to work, Mattel emphasizes that the Captain Power system can be played independently of television. Children can shoot at each other's jets to score points and cause ejections anytime. Moreover, "battle and training" videotapes with 15 minutes of interactive footage will be sold separately, further weakening the link between the product and a particular half hour of commercial broadcast time.

While Captain Power is a variation on conventional video games, Axlon's Techforce ($250) can be seen as a derivative of another well-established product category: radio-controlled vehicles. Each of two transmitter consoles provides independent control of up to eight wheeled figures, or "progs"; pressing different buttons on the consoles moves them in different directions, or fires an infrared gun. All radio signals are at the same frequency, and individual progs are "addressed" with digital encoding.

There are several ways to play with the system when the TV show—*Techforce and the Motomonsters*, slated for the fall—is not on, explains Anthony Jones, Axlon's vice-president for product development. In one mode, each player programs in a series of moves for his team of figures. (For example: figure number 1, go forward, then right, then fire). When the start button is pushed, the figures go into action; any that is hit with an infrared beam goes out of commission for the next 10 seconds of game play. "It's like playing 'battleship' all over your living room floor," says Jones.

Baby Talk responds to being fed, handled, or spoken to with a synthetic-speech repertoire of about 20 phrases.

When the TV show comes on, some of the wheeled figures will act out the role of the bad guys ("demon progs"). At the start of the show, these demons must be arrayed about three inches apart in front of the TV set. Buried in the program's audio track will be brief digitally encoded bursts of sound that a sonic decoder will translate into radio signals to drive the demon progs. These progs will then move around the floor to match the actions of their on-screen counterparts. The child will then maneuver the "good" progs in battle against the TV-controlled band of demons.

The progs emulate more than what can be seen on screen, however. When a character goes off screen in the show, the corresponding prog will continue to move around the floor—giving the child a clue as to what may happen next during the show. For example, it may appear during the cartoon that the enemy has been chased off screen and is likely to meet his death. The demon prog, however, gets up and starts rolling back into the action. One big question about Techforce is whether it will appear at all. The product was first demonstrated early in 1986 and was supposed to come out last year. Axlon's failure to produce it has cast some doubt in the toy industry on the company's capabilities.

For kids who feel they can improve on the TV programming served up to them by the adult world, Fisher-Price will bring out a fully functional camcorder in September at a price—$150—that can practically be covered by savings from a paper route. Fisher-Price's key design decision was to settle for a much poorer picture than the grown-up video cameras offer. Images will be in black and white, with resolution of only 90 × 30 pixels, about a third as sharp as with conventional camcorders. This drastic reduction in information content allows the image to be stored on ordinary audio tape. In addition to being less bulky, audio

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Fisher-Price's $150 camcorder will record 11 minutes of black-and-white video on a standard audio cassette, says design chief Fisher (far left).

tapes are played and recorded on with a stationary head, which is cheaper to manufacture and more rugged than the rotating heads needed with videotape. A standard 90-minute cassette will store 11 minutes of video (5½ minutes per side). Sound quality will be comparable to that of Fisher-Price's children's tape recorder—good but not hi-fi. Sound-deadening material will insulate the built-in microphone from the motors, which will zip the tape through the machine at a speed comparable to "fast forward" on an audio deck. For playback, the camcorder can be hooked directly into a TV set (no VCR is necessary).

Simplicity governs the design. There's no focusing mechanism, either manual or automatic. Fisher-Price gets away with that because the charge-coupled-device image pickup is sensitive enough to allow an optical system consisting of a single lens of very narrow diameter. This small-aperture lens is permanently focused on anything from four inches to infinity. The only exposure adjustment will be a neutral-density (gray) filter, which can be flipped over the lens for outside shooting and removed for dimmer indoor lighting. "The idea was to make it inexpensive, easy to use, and bomb-proof," explains Robert Fisher, Fisher-Price's senior manager of design engineering.

A camera is not the only way to store a child's creativity on the TV screen. Photon manufacturer LJN Toys is introducing a high tech "Etch-a-Sketch" that lets you paint pictures on the TV screen in up to 16 colors. In its most open-ended mode, the Video Art system allows freehand drawing on a blank screen. Alternatively, software cards can be inserted into the unit to turn the TV into an electronic coloring book, with as many as 18 pages of predrawn figures. Pictures can be stored on a videotape to make an electronic scrapbook of the child's work (a separate VCR is necessary).

Video Art is unusual among the latest high tech toys in that it solicits the child's creative input. Most others, despite claims of interactivity, tend to channel play in directions conceived by the toy designer. But it's "nonsense" to say that these toys will stifle children's imagination, says Susan Youdovin, a child development specialist in St. Petersburg, Fla., who has consulted with toy companies for 10 years.

Children, she asserts, will use whatever toys they have as springboards from which to launch their own fantasies. "They'll listen to a talking doll for a couple of minutes, then take off into their own imaginary world," says Youdovin. And besides, she says, there's nothing wrong with the occasional toy that lets the child be passive. After all, she says, "kids need down time too." □

Herb Brody is a senior editor of HIGH TECHNOLOGY.

For further information see RESOURCES, *p. 66.*

LIFE WAS SIMPLER THEN. IT WAS ALSO SHORTER.

This young man lived life at a slower pace in 1849. That was the year Pfizer first opened its doors. His life expectancy, however, was less than 40 years.

Today, thanks in part to health care research, a man can look forward to a life span of 72 years or so, a woman 78. And those years are richer and healthier than our predecessors ever dreamed.

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Companies like Pfizer are rising to the challenge, marshalling the latest medical and technological knowledge to discover and develop new pharmaceuticals. Last year more than four billion dollars was spent on pharmaceutical research in the United States.

Its goal: to help people live longer, healthier lives. And Pfizer has made a firm commitment not only to pharmaceutical research, but also to hospital products, agriculture, specialty chemicals, materials science and consumer products.

Pfizer's work in these fields could have extended this young man's life and improved its quality. Pfizer's dedication to research will help make that happen for today's men and women, young and old.

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Inside the High Tech Apple

Four by Five

People think of New York as the financial, corporate and communications hub of the nation—but not as a vital center of high technology. But that doesn't detract from the scope of New York City's high tech community. As Dr. Joshua Lederberg, President of The Rockefeller University, points out in one of a series of interviews with business, government and academic leaders presented here, there are about 225,000 people employed in high tech jobs just in the five boroughs. And the New York-New Jersey metro area has over 800,000 high tech workers compared to Silicon Valley's 260,000 and Route 128's 200,000.

We also learn upon examining the Bureau of Labor Statistics data of the New York-New Jersey Metropolitan economy, that approximately 14.6 per cent of all regional jobs can be classified as high tech—a very respectable percentage. In these industries, the rate of employment growth between 1975 and 1981 was about 10 percent, compared to nine percent growth in the 17-county region. In at least nine high tech industries—including instruments, electronic components, electrical machinery, communications, engineering and architectural services—the rate of growth in the metropolitan area exceeded that of the nation.

The fact is, New York City is enjoying a boom, and City officials are working to ensure that this new prosperity is distributed throughout the boroughs. As Alair Townsend, the Deputy Mayor for Economic Development, points out, the City is busy revitalizing the Bronx and building a huge new financial/business center in Brooklyn just across the bridge from Manhattan.

The following series of interviews will further demonstrate the determination of the public and private sectors to succeed in the New York metro area. The outlook for the High Tech Apple augers well for continuing expansion.

Interview with Alair Townsend, Deputy Mayor, Economic Development New York City

Q: What incentives does the city offer to businesses in general?

A: Before I answer that, it's critical that the outside business community understands that Mayor Koch turned the city around, that he made necessary economies. We're in our seventh year of balanced budgets based on GAAP (Generally Accepted Accounting Principles.) Our good fiscal reputation has been restored. So we can begin to think in terms of long-range, capital improvements, education. Our

Alair Townsend

schools are targeted for billions of dollars worth of improvements.

High tech firms are fully integrated into our overall economic strategy. We help them to succeed in a variety of ways. We offer property tax exemptions for up to 22 years to companies that build new facilities or rehabilitate old ones north of 96th Street in Manhattan and in the other four boroughs. Energy costs, which can be expensive for high tech firms, are reduced under incentive plans by Con Edison, Brooklyn Union Gas and New York City.

We can also help a high tech company get started and financed, beginning with site selection. For example, our real estate assistance unit will provide you with a free listing of industrial and commercial space for rent or sale in whatever area of the City you are considering.

The City also owns land and we'll work with you to buy or lease it, no matter how specialized your needs. For example, Enzo Biochem came to us with a set of unique specifications. They wanted to be in the heart of a medical complex. We arranged for them to renovate an old morgue on the Bellevue campus. They in turn will offer space to other high-tech firms.

Q: What other efforts do you make?

A: For small firms...there's the Willow Avenue incubator in The Bronx. It's a facility that offers small blocks of space, shared service, xeroxing, on-site managers, funded by the City and the Port Authority (of New York and New Jersey). One thing about New York: you don't have to look around for funding. Venture capital is readily available for those who need it.

Q: Protocom Devices, Inc., is a small start-up that's prospered.

A: They were at Willow Avenue and got $4 million from the Port Authority to build in our Bathgate Industrial Park in the South Bronx. Ramon Morales of Protocom will tell you how advantageous it is for a data communications firm such as theirs to be located in New York. He'll tell you telecommunications is the city's lifeblood, so his market is here. The buyers are here, the universities are here—the whole infrastructure a company like that needs to grow.

Q: So a goal is to strengthen residential and business development simultaneously.

A: Metrotech is an example...live near your job. Here are nearly 3 million square feet of space for research and offices in a campus environment in the heart of Brooklyn with access to research labs, engineering training. They'll give you custom-designed offices at rents that are a fraction of Manhattan's. And you've got the benefit of being associated with Polytechnic Institute, its libraries, training...

Q: What else is the city doing?

A: A lot of things. Anybody with a question can call 212-NY-MAGIC, our hotline. Or they can write me at the Office for Economic Development, 17 John Street, New York, NY 10038. But we've got programs that will cut through red tape, find and train employees, help you if you're a company run by a minority or woman.

We've got low-cost loans to close the gap between conventional financing and your total project costs. Our Revolving Loan Fund has made over $38 million in such investments. The State Job Development Authority has made $29 million more. We've also got below-market rate subordinated mortgage loan help. We use Federal Urban Development Action Grants to make these loans. Since 1978, we've extended $170 million to a total of 64 projects. In turn, they've leveraged another $1.2 billion in private dollars.

Q: Anything else?

A: The Teleport. The City is spending $10 million to provide the services and roads for the new Staten Island teleport. Readers of *High Technology* will understand that a teleport is as vital to processing information as seaports and airports are to moving commerce. It's the world's first communications center, office park, and so on with a fiber optic network linked to satellite transmission facilities.

The Port Authority originated the concept and is overall developer. It's a 350-acre site on the expressways about 10 miles from Manhattan. The Port Authority has set aside $57 million on site preparation and infrastructure for the first phase, about 100 acres. The 150-mile fiber optic network serving the region began operating in April 1985. It was completed the following December to Manhattan, Brooklyn, Queens and to New Jersey—Newark, Jersey City, as far as Princeton.

Q: What kinds of companies make use of it?

A: It's caught on very fast. There are more than 25 companies already. You've got long-distance carriers such at ITT, U.S. Sprint, RCA, AT&T, broadcasters, financial companies such as Merrill Lynch, Dow Jones, Bankers Trust, those kinds of participants.

Q: Much of their data is transmitted by satellite.

A: Seven earth stations now are operating. Three of them serve broadcasters like Catholic Telecommunications Network of America, Hughes Television, and so on. COMSAT and TRT Communications own a fourth. As information becomes increasingly vital to business services, you'll find New York City first here. I mean, as the financial and communications capital of the world, we have to be in the forefront.

Interview with Dr. Joshua Lederberg, President, The Rockefeller University, and Chairman, The High Tech Committee, New York City Partnership, Inc.

Q: People don't normally think of New York as a high-tech center.

A: That'll change. Eventually, the image will catch up with the reality. The issue is partly one of proportion—high tech is a smaller part of the total economic and population basis than other centers. Even so, New York's image doesn't do credit to the reality. You should think of New York as the hub of a 400-mile long metroplex corridor, a 40-million person market, not 10-million. This market has four of the

"New York. It's not just where I work, it's where I belong."

The energy of New York, the pace, the excitement. You want to be in New York, but running a business here can be tough.

Con Edison understands the realities of running a business in the city. So we developed Project Appleseed.

Project Appleseed is a special, reduced-rate program designed to encourage the growth of businesses in areas of New York where our facilities are underutilized. It works in three ways:

Appleseed for special areas. If you start, relocate or expand your business in any of our special areas in New York, you could be eligible for significant reductions of up to 30% on your electric bills and 21% on your gas bills. Introduced in 1981, Con Edison's reduced-rate programs are contributing to the revitalization of 18 areas of New York City.

Appleseed for vacant buildings. If you move your business into a vacant building located in certain sections of New York City and Westchester County, you may qualify for reductions of up to 12% on electricity and 21% on gas.

Appleseed for new buildings. If you choose to build or move into a new building in areas of New York City and Westchester, similar reductions apply—up to 10% on electricity and 21% on gas.

And you could qualify for further electric and gas savings through New York City's own Energy Cost Savings Program.

Project Appleseed. Because we want your business. Here. In New York. To find out how Project Appleseed can work for you in New York and in Westchester County, call John Manak, Manager of Area Development, at (212) 460-4000. Or write to him at Con Edison, Area Development, 4 Irving Place, New York, N.Y. 10003.

Con Edison PROJECT APPLESEED

THE ENERGY OF NEW YORK

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The High Tech Vision Lives in New York

There are great opportunities on the horizon for high technology business in New York State. In fact, more than 80 of the largest corporations in the United States, including IBM, GE, Grumman, Kodak, and Corning, already call New York State home; if the State were a nation, it would rank 11th in the world from an economic standpoint.

But New York is also home to the fastest growing small business sector in the nation with thousands of companies starting up here--like Applied Robotics Inc., Fifth Generation Computer Corp., Clean Room Technology Inc., Sono-Tek Corp., and Laboratory MicroSystems Inc. And New York has the resources to help these entrepreneurs achieve their vision.

New York's labor force of over 8 million is among the most productive in the United States. That's according to the U.S. Census Bureau.

For high technology business in particular, New York is fertile ground. More than 250 degree granting institutions produce over 25,000 graduates in nearly 200 different scientific and technical fields every year.

And New York State government is behind entrepreneurs every step of the way. With an array of programs to help them adapt new technologies to the workplace, obtain seed funding for new ventures, pursue innovative research and development, and secure long-term major financing for growth and expansion. All working to implement New York's innovative technology policy.

If you'd like to know more, contact the New York State Science and Technology Foundation at (518) 474-4349. We'll be happy to assist you with the information and resources that can help your business move ahead.

Because in New York,
we can see beyond the horizon.

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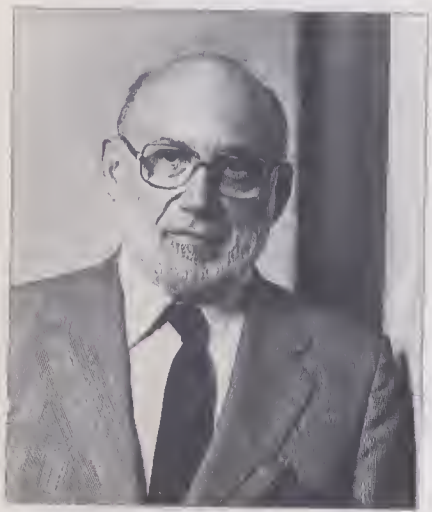
ten metros: larger than California and Texas combined.

Q: Is that significant?

A: Absolutely: one fifth of the American population concentrated in a 200 mile semi-circle around the city! That location bears on shipping, costs, purchasing power, buying clout, skill, power, availability at every level. The total personal income of the greater New York region for 1983 was $270 billion, nearly twice that of California's $150 billion.

Q: Can you maintain your leadership in high tech jobs?



Dr. Joshua Lederberg

A: We have to! High-tech jobs are vital to our growing service industries—banking, telecommunications, medicine, education. With a determined effort, New York can have 400,000 high-tech jobs by 1995.

Q: Like much of the rest of the country, manufacturing levels have declined in New York City, costing some high tech jobs. According to an in-depth study by Booz-Allen & Hamilton, the city lost 4,000 high-tech jobs between 1977 and 1983.

A: Yes, but we have seen non-manufacturing jobs increase. Close to 40 industries in the private sector are classified as producing high tech goods or services. In addition to our 240-plus computer-related services firms and 40-50 biotech-based companies, we're extraordinarily strong in high tech services: telecommunications, broadcasting, engineering, architecture consulting, and R&E.

New York is unique in its concentration of high tech users, as opposed to technology developers who need continuing technology innovation and service support. These users are a rich, growing market for high tech services and manufacturing. That Booz-Allen report you mentioned notes that a carefully targeted program to build on the high tech job base could generate up to 125,000 new jobs in the next decade.

Q: What is the Partnership doing to spur this develoment?

A: We're committed to enacting the Booz-Allen recommendations. Our committee found the city's assets and competitive advantage provide a solid foundaton for building our high tech base, especially in computers and biotechnology.

The Partnership has been designated by the New York State Science and Technology Foundation as the Regional Technology Development Organization for the city. We're assembling a comprehensive data base of high tech businesses, university research resources, and public and private sector resources. We're the focal point—a coalition of business, academic and non-profit leaders—and we've distributed our strategic plan known as The Blueprint for action to expand and diversify our business base.

Q: So this group focuses on critical needs?

A: Examples: we need to develop more high tech R&D incubator space, especially for telecommunicaitons and computer-related service companies. We need to offer more incentives to attract high tech ventures. We need to help the city improve its housing, education, and public services.

Q: What kind of interaction do you have with the State?

A: As allies, going down the same road. Vincent Tese, Chairman of the Urban Development Corporation, is a member of our committee. He recently launched the Economic Development Zone Program. The State's also created a low-rate loan program to help manufacturers modernize and retool. Governor Cuomo is pushing hard for a statewide fiber-optic network and funding more university research. They've also just doubled the lending ceiling of the state's economic development bank.

We have a golden opportunity to develop high technology as a key component in diversifying the economic base and maintaining New York as Number One among world-class cities.

Interview with Herbert Morse, Vice Chairman-New York Region; and Michael Plansky, Peat Marwick Main & Co., Partner In Charge, High Technology, New York City.

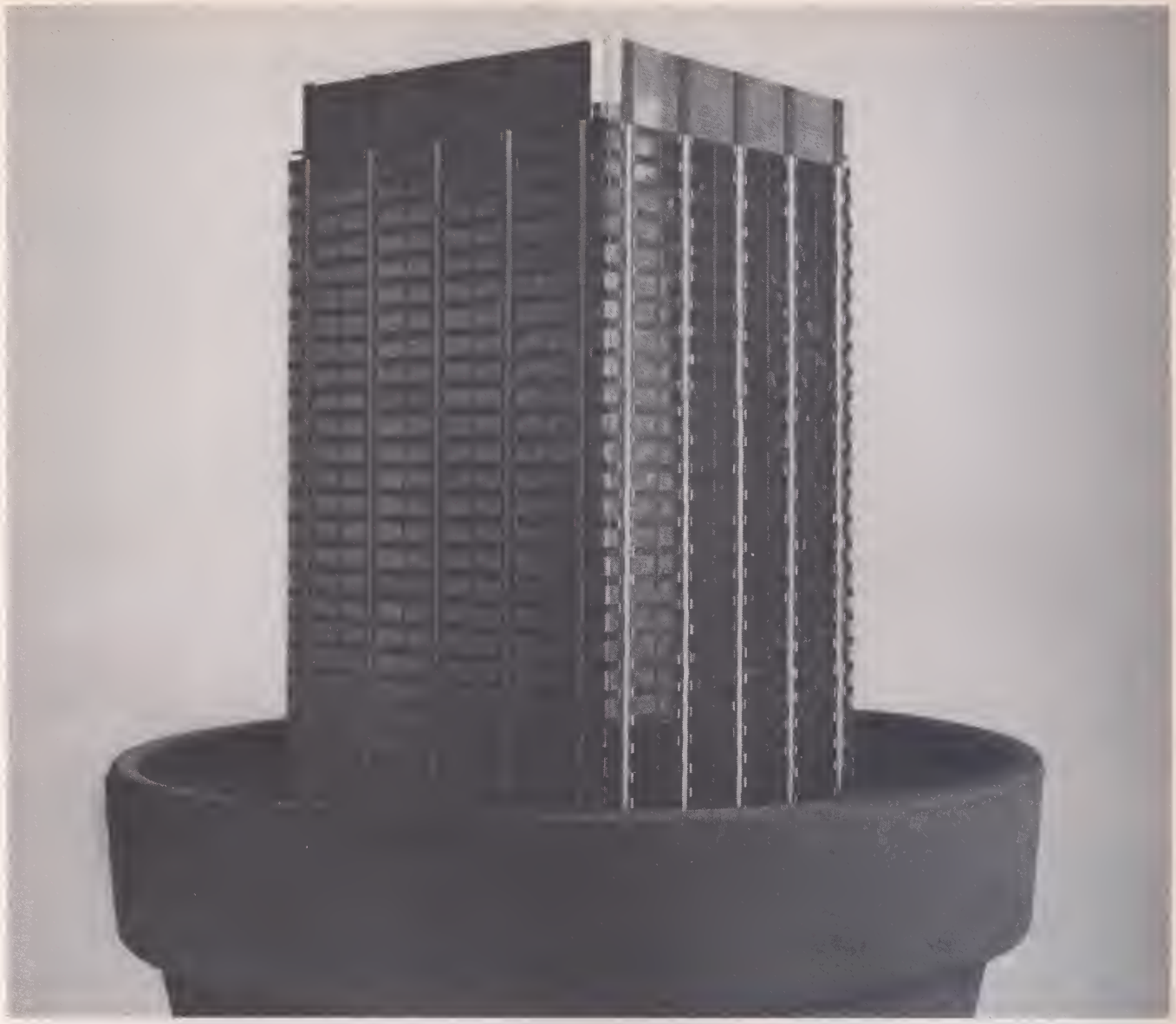
Q: Is New York really a high technology center?

MORSE: Indeed it is. There are over 1,000 high tech companies in the five boroughs of the City alone, with numerous others in the metropolitan area, employing hundreds of thousands of individuals. The City's economy in general—and the high tech industry in particular—is principally service oriented rather than manufacturing oriented. And the industry is not as visible in New York. Companies are not clustered together. Instead, they occupy space in anonymous buildings in lower Manhattan, the outer boroughs and the rest of the metropolitan area. Collectively, though, they comprise a thriving high tech industry. The challenge is to enhance the image of the City as a high tech center and—more important—to leverage the tremendous resources that we have here.

Herbert Morse

Q: How can that be done?

MORSE: The infrastructure for a flourishing high tech industry exists here—strong technical universities, financing availability, supportive State and City government agencies, professional associations, public relations firms, law firms and accounting firms. However, the network needs to be more clearly defined, with all of these groups working together more closely.



Our Soil Grows The Biggest Plants.

We're talking about Brooklyn, Queens and Staten Island—Brooklyn Union's New York.

One of the newest and biggest developments is MetroTech, planned for downtown Brooklyn, right in our own backyard.

MetroTech is a 4.3 million square foot academic, commercial and high technology office complex being developed by Forest City, MetroTech Associates, and MetroTech, a non-profit affiliate of Polytechnic University.

In addition to a 100,000 square foot building to house Polytechnic's Center for Advanced Technology in Telecommunications and Science, MetroTech will also include ample space for technology-oriented businesses who need offices, commercial space, and research and development facilities.

To learn more about MetroTech and other high technology centers in Brooklyn, Queens and Staten Island, call our Director of Area Development, Michael J. Teatum, Jr. at (718) 403-3370. You can also write to him at Brooklyn Union Gas, 195 Montague Street, Brooklyn, New York 11201.

Brooklyn Union Gas

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PLANSKY: In fact, the New York City Partnership has done a great deal to integrate these resources, and will continue to act in its vital capacity as facilitator.

MORSE: People must focus on the issues. We at Peat Marwick, for example, have identified the metropolitan New York area as a strategic high tech region because of its enormous user market, vast telecomunicatons network, proximity to the financial services industry, medical research capabilities and the general vitality of the City. In response to the existing market and its potential to grow, we have committed significant resources to serving this particular market.

Q: What are these issues?

PLANSKY: There are perceptual issues concerning the quality of life in the City and real issues, including the high cost of living and working in New York and the high tax rate. An effective marketing campaign must be undertaken to deal with perceptual issues concerning the quality of life. But the real issues should be addressed prior to promoting the City as the high technology center that it is.

Michael Plansky

The tax burden for companies doing business in New York City is one of the highest in the nation. However, there are various tax and economic incentives to encourage companies to do so, including real property tax abatements, tax credits for relocating to the City, and immediate expensing of all qualified research and development property.

The State is currently moving on several fronts to reduce the burden for corporations. Consideration is being given to eliminating the corporate tax on capital, the alternative tax and the 90% disallowance of the deductability of the interest paid to certain shareholders, and well as reducing the tax rate. These are all positive steps for New York's economy in general, and particularly for high tech companies that want to do business in New York State. To become more competitive with neighboring areas, the City should take parallel steps.

Additonal incubator facilites should be created to help high tech start-up companies cope with the high cost of doing business in this area and to provide the necessary back office support that companies need in their early stages.

Q: But won't all this result in a substantial loss of revenue?

PLANSKY: It shouldn't. Lowering taxes could attract companies to the City, thereby expanding its tax base. A short-term loss of revenues might not be detrimental, as the City is currently operating at a surplus. Additionally, the Federal Tax Reform Act of 1986 will create a windfall unless the City restructures its current tax system.

Q: Why is an accounting firm so involved with high technology in New York City?

MORSE: As a firm, and as individuals who live and work in New York, we obviously have an interest in the economic well-being and future viability of the City. High technology—particu

BROOKLYN, OUTER BOROUGHS HOLD DEVELOPMENT PROMISE

"We've got some of the best new office locations in the New York metropolitan area," Michael Teatum Jr. says proudly, "and they're better situated than either Boston or Silicon Valley."

Teatum is the Director of Area Development for Brooklyn Union Gas, the big utility servicing that borough, Staten Island, and about two-thirds of Queens. And he can look out his window and see one of those centers going up. It's the twenty-one story, $143-million office tower under construction in downtown Brooklyn's Pierrepont Street with Morgan Stanley as principal tenent.

But that's just one of a dozen major new complexes taking shape in this city of two million just a bridge away from Wall Street. Taking advantage of its location, superb highway net, quick access to both LaGuardia and Kennedy airports, inexpensive office and affordable housing space, world-class Atlantic port, and building on its two reknowned technology schools, a new Brooklyn is rising on the horizon.

Teatum cites a number of major new projects taking shape within a few miles of the big utility's downtown headquarters, including Atlantic Terminal/Brooklyn Center, a two-phase $500 million complex offering 3-million square feet of office space, 643 apartments, and stores, to go up in the heart of downtown; and Metrotech, the sixteen acre technology office headquarters and research park that will link the facilities of Polytechnic Institute and the New York State Center for Advanced Technology in Telecommunications. (Brooklyn Union Gas will relocate its headquarters there.)

Unlike densely-built Manhattan, the North Brooklyn section alone offers more than 500,000 square feet of open land for new construction. Lots ranging from 2,500 to 200,000 square feet are available at prices that are competitive with suburban New Jersey or Long Island.

In additon to a wide variety of services offered by the City, Teatum says Brooklyn Union Gas will help interested companies identify potential sites.

"We do the legwork for them. We maintain contacts with the best industrial and commercial realtors." Teatum goes on to say, "If a company is interested in Brooklyn, we'll do a site survey to give us a precise idea of their needs. We will screen prospects for them, go out on location with them, conduct an energy evaluation, and help them obtain financing, whether it's for construction, mortgage financing, or capital equipment.

Since the utility is very conscious of controlling energy costs, it provides a special rate—known as EDGAR for Economic Development Gas Rate—which is a 25% discount off the standard if the firm relocates in an economic development zone. The new tenant can also take advantage of the city's 20% discount, giving it a total energy writedown of 45%.

larly in the areas of computer-related industries, telecommunications and medical technology—can provide numerous jobs, thus helping to assure New York's future competitiveness.

PLANSKY: We've addressed the needs, concerns, opportunities and challenges of a great many high tech companies in all phases, from start up to maturity, and this remains a key area of our practice. Going far beyond traditional accounting, auditing and tax services, we act as business advisors, lending assistance in such areas as identification of management team members; business and tax planning; working captial and cash management; identification of financing sources; and executive compensation and benefit strategies. Our recent affiliation with Regis McKenna, a premier high tech marketing firm, expands our ability to provide public relations and marketing services to burgeoning high tech companies.

Interview with Edmund T. Pratt, Jr., Chairman of the Board and Chief Executive Officer of Pfizer Inc.

Q: How important is technology to Pfizer?

A: Central to everything. Last year we spent $336-million on R&D. R&D is the heart of a modern pharmaceutical firm. We have more newly discovered drugs in the works than at any time in our history. We got marketing approval in Switzerland and New Zealand for Carduran, that's for the treatment of hypertension. And we've filed in the U.S. for marketing approval for Procardia GITS (gastrointestinal therapeutic system). Procardia is already the best-selling anti-angina drug in the U.S. and ongoing research has yielded new indications for Feldene, the first once-daily non-steroidal anti-inflammatory for arthritis. We first launched that overseas in 1979, again, the product of intensive research, technology. Now we are filing to use Feldene as an analgesic. All our major drugs—Minipress, for high blood pressure, Cefobid, and antibiotic, Glucotrol, an antidiabetic—all inextricably linked to the quality of our technological knowledge.

Q: You are growing-

A: Oh, yes; gathering momentum. Sales topped $1 billion in 1972 for the first time. By 1977, they exceeded $2 billion. In 1980, they were $3 billion,

Edmund T. Pratt, Jr.

and last year we established a record $4.47 billion. The statisticians tell us we're now the third or fourth largest pharmaceutical company in the world and according to *Fortune* magazine we're the 24th most profitable company in the U.S. Today we have about 40,000 employees spread over 140 countries.

Q: But your headquarters are here in New York.

A: We have a commitment to the city. We have over 2,200 people in our Manhattan office. We have 750 more in our Brooklyn plant in East Williamsburg and over 250 in the other boroughs. We're ranked as the largest manufacturing employer in New York.

Q: Mayor Koch once said, "When New York City was down and out and corporations were leaving in droves, Ed Pratt stood up like 'Horatio at the bridge' to defend the City and to stem the tide." Actually that decision was sort of a turning point for Pfizer and other corporatons...

A: Well, in the early 70s we took a long, hard look at the City, at our options. We made an in-depth analysis of several different locations. And we took into consideration, actually, 100 different factors for each of them—geography, economics, labor costs, quality of life, risk factors, schools, shopping, taxes, and so on. We looked particularly hard at what life would be like for our employees each day. When we finished, we concluded that while New York City had its problems on balance it had much more to offer, so we stayed.

Q: So the decision to remain was not based on sentiment or pressure?

A: On the contrary. Before we undertook our study, we had eight members on our executive committee and all of them had voted to leave the city. But we decided to make the analysis. When all the facts were presented, every one of the committee members voted to stay.

Q: What kind of support have you had from the city administration?

A: A lot in attacking the problems of deterioration. The Broadway Triangle Industrial Park is taking shape. Our Brooklyn plant is the anchor for this development. We'll be creating a half million square feet of new industrial space. We hope to be generating between 800 and 1,000 new jobs.

In cooperation with the New York City Partnership we're going to have several hundred units of low- and moderate-income housing going up. I was glad to have the opportunity to be a founding member of the Partnership and all it does for this city. I think last year they actually came up with over 30,000 summer jobs for youth...they're putting up about 1,000 housing units a year for middle-class families...

Q: Apart from strengthening the city's technology base, what are the other items at the top of your agenda?

A: For one thing, we have a strong commitment to high technology in the public policy arena. We want to protect this country's technological lead at every level, national and international. Dr. Gerald Laubach, our president, has served on President Reagan's Commission on Industrial Competitiveness. I've served as chairman of the Advisory Committee for Trade Negotiations and on the President's Export Council.

Q: I take it your view is that government should be a help, not a hindrance.

A: Yes, but we need government support if we are going to remain competitive in a tougher, global marketplace. We are still powerful—our land, our resources, our people, our ability to innovate and create, our intellectual promise. The Japanese are masters at business-government cooperation for global market penetration. We can learn something from them.

Interview with John R. Manak, Manager, Area Development, Consolidated Edison Company of New York, Inc.

Q: What's that?

A: It's a Big Apple pin symbolizing Project Appleseed and New York. It's our area development program. We offer reduced rates for qualifying firms, both electric and gas. Companies that start, relocate or expand operations in certain economically disadvantaged areas are eligible.

John R. Manak

Q: The idea being?

A: To spur economic growth and job creation for participating firms where Con Edison has underutilized facilities. We estimate that the 6,100 companies in Project Appleseed have created 30,300 jobs since the program was launched in 1981.

We started in South Bronx, in Brooklyn neighborhoods like Williamsburg, Bedford, Bushwick, Red Hook, East New York, and Coney Island. In 1984, we added more to the South Bronx, Harlem, Corona, and Ridgewood in Queens. Also portions of Staten Island, and expanded areas in Brooklyn.

Q: Queens? That surprises me.

A: Absolutely. Queens is now one of the top 15 industrial counties in the entire United States. Queens has 2,700 manufacturers and 2,600 wholesalers. It's a great incubator for industries. Long Island City has been a manufacturing stronghold for years and it's booming now. It's the hub of the eastern motion picture industry. The film industry started out there and those studios have been modernized. Air freight around Kennedy and LaGuardia is booming, and there are lots of good industrial sites available. Queens is nearly 120 square miles, with lots of beautiful residential neighborhoods.

There are more than 1,000 manufacturing companies doing business in the Bronx, too. Lots of small manufacturers. In fact, the Big Apple is made up of little apples. We all know about approximately 100 "Fortune 500" companies with headquarters in the city. But it's the smaller firms that provide more than half the jobs. About 98% of the manufacturing businesses in the city employ fewer than 100 workers.

Q: So you can provide them with lowcost space?

A: When you consider the overwhelming majority of our manufacturers are small companies, many startups, you can see what these gas and electric power reductions can mean to them. For many that move into the disadvantaged areas, counting our reductions and the City's energy cost savings program can cut a $12,000 electric bill to $5,880. That's more than half.

There's a special rate for qualified firms that reoccupy vacant commercial and industrial buildings throughout our service area, in the five boroughs for electricity, and also gas rate reductions in Bronx, Queens and Manhattan. You could qualify for reduced electric rates if you move into newly constructed space, too.

Q: How long will the special rate be in effect?

A: Through the end of 1994. Something else I might point out. We have not had a rate increase for the past four years. Actually, we've just had a three per cent rate decrease. And our Chairman Arthur Hauspurg recently signed an agreement in Albany with Govenor Cuomo to pledge there will be no rate increase for another three years. So that's seven years of actually decreased rates.

Q: Who do business executives call for further information on Project Appleseed?

A: Call me directly: (212) 460-4153.

Q: Thank you.

Interviewer Sherwood Ross, Public Relations Director for High Technology Magazine, writes a weekly column on business development for the Reuters News Service.

New York? A high tech center? You bet.

Wall Street. Broadway. Madison Avenue. Fifth Avenue. Everyone knows New York is a financial center, a cultural leader, an advertising trendsetter, and home to the most famous names in retailing.

But we raised a few eyebrows when we started asking questions about high technology in the Big Apple. What we found is that New York is home to no fewer than 1,000 high tech companies. It seems that the city has a lot to offer high technology—and vice versa.

To meet the special needs of high technology companies, we took action. Peat Marwick was the first professional accounting firm to start a specialized high technology practice—nationally and locally. We've dedicated ourselves to making New York a high tech center.

Now, when you talk high tech here, you're talking Peat Marwick. We speak your language, and we know what it takes to make high tech profitable in New York.

If you would like to know more, call Michael Plansky, partner in charge of the New York high technology practice at 212-872-5724.

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345 Park Avenue
New York, NY 10154

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INDUSTRIAL ADHESIVES START TO SPREAD

Since the advent of epoxies in the 1950s, adhesives have promised a number of advantages for manufacturers: more even distribution of stresses, the elimination of mechanical fasteners (and hence simpler assembly), and savings in cost and weight. Several factors have prevented adhesives from sweeping industry at large—uncertain durability, for example, and the need for different production processes from those already set up for conventional welding, rivets, nuts, and bolts. But glue is starting to see wider use, especially as manufacturers increasingly build their products from materials such as plastics and composites, for which the traditional methods are unsuitable.

Automaking robots are starting to trade in their welding guns for glue dispensers as cars are built more from plastics, aluminum, and composites.

The construction industry offers several instances where adhesives are directly replacing conventional fastening techniques. Mastics—viscous adhesives with either a latex or a solvent base—have eliminated up to 75% of all nailing in the construction of houses, according to Goodyear, which produces such adhesives. They also are widely used in constructing factory-built houses, which are easier to transport when there are no nails to pop.

Epoxy-based mortars have found considerable use in assembling massive prefabricated structural sections of bridges. In one technique, for instance, the sections are strung together with steel cables to form long beams supported by widely spaced piers. Adjacent sections are adhesive-bonded to carry the vertical shear loads, while the cables take the bending and tensile stresses. This method has been used to build more than 100 stadiums, viaducts, and bridges, including the Costa e Silva bridge near Rio de Janeiro—the longest in South America. Although more expensive than the portland cement conventionally used, the epoxy mortars are justified by their higher strength and reduced brittleness.

In automobiles, adhesives can reduce noise and vibration by forming continuous joints. Formulations for this purpose—as in the Ford Thunderbird—typically displace braces and sound deadeners costing 10 times as much. Adhesives could also enhance design flexibility. Bodies today are designed for welding, with joints that suit welding operations. But if engineers were to apply adhesive-bonding approaches at the developmental stage, they could eliminate such design compromises as the gaps in structural components that are required for welding-gun access, and thus provide lighter and stronger assemblies. What's more, the same ovens used to dry paint could also serve as autoclaves to cure epoxies and urethanes.

A vehicle glued together can be surprisingly strong. Recently, a 250-pound motorized golf cart collided with a pickup truck that was going 20 miles an hour. The truck sustained some $2000 in damages. The two-passenger cart, a Gashopper from Moto America (Miami) that had been put together with adhesives, fared better. "We repaired it in about five hours," says Frank Boulton, the company president. "It had very minor damage because the adhesive elongated, spreading the load over a large area. It was clearly a case of a lighter vehicle being stronger than a heavier one."

There are two major problems with the use of adhesives in automobile production, however. One is that the steel used in cars arrives from the mills coated with lubricants as preparation for stamping. The only adhesives that work on such poorly prepared surfaces are polyvinyl chloride–based plastisols, which are suitable only for light duty, as in the bonding of hood panels, and reactive acrylics, which are not as strong as epoxies and weaken further under prolonged exposure to gasoline and other hydrocarbons. (Cleaning the lubricants off the stamped parts would add a production step that would increase overall cost.)

The other difficulty with automotive adhesives is durability. The corrosion caused by rain and road salt can make a bonded area start to separate; once begun, peeling generally continues until the joint fails. "We don't have the confidence" in adhesives that would permit recommending a major switch from welding, says David Garrett, who heads GM's Fisher Body Materials Development and Testing Laboratory. Similar caution prevails at Ford, where engineers contend that significant substitution of adhesives

by T. A. Heppenheimer

COURTESY CIBA-GEIGY

ADDRESSES

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Goodyear
1144 E. Market St., Akron, OH 44316, (216) 796–2121

Loctite
999 N. Mountain Rd., Newington, CT 06111, (203) 246–1223

Lord
2010 W. Grandview Blvd., Erie, PA 16514, (814) 868–3611

for welding will not occur until the 1990s.

Adhesives are likely to play a larger role in cars as automakers turn to alternatives to steel. Plastics, composites, and aluminum—increasingly favored for their light weight and corrosion resistance—require adhesives because they cannot be welded. Other design changes also call for adhesives. A recent innovation, for example, involves bonding front and rear windshield glass directly to the car body so that the glass becomes part of the load-bearing structure, thus improving vehicle aerodynamics. Such flush-mounting of glass panels, featured in Chrysler's minivans and Ford's Taurus/Sable models, is possible only with adhesives.

The Swiss adhesive maker Ciba-Geigy recently set up a center in Madison Heights, Mich., to encourage the use of adhesives in auto manufacture. The center features a structural adhesive and sealant laboratory, along with a pilot plant for new product development. It also focuses on the use of automated equipment to apply adhesives. Robots, for example, can be guided by machine vision to dispense an extremely fine and precise bead, and thus could aid tremendously in integrating the bonding process with the rest of an automated factory.

The aircraft industry has gone further with adhesives than car makers have. Because aircraft aluminum does not lend itself to welding, planes traditionally have been riveted together; the rivet holes are the starting points for corrosion and fatigue cracks. Moreover, in contrast to the oily steel used in automotive assembly, aircraft aluminum undergoes a meticulous surface treatment with phosphoric acid that gives an "excellent substrate for extremely durable bonds," asserts Corey McMillan, manager of materials technology at Boeing Commercial Airplane (Seattle). During the 1970s, under an Air Force contract, Douglas Aircraft (Long Beach, Cal.) pursued a program called Primary Adhesively Bonded Structures Technology (PABST), in which aluminum sheets were glued directly to segments of the main structural beams; the beams were then bolted together to form the complete fuselage (HIGH TECHNOLOGY, Sept. 1983, p. 67).

But in production of large commercial aircraft, adhesives have so far found a more limited application. They are primarily used in bonding reinforcing layers of aluminum to the skin of the fuselage—a difficult task for riveting machines, which

MANUFACTURERS STICK TO FIVE BASIC GLUES

More than 100 companies produce over 25,000 different types of adhesive, but some 95% of the applications in manufacturing are handled by five classes: epoxies, urethanes, acrylics, anaerobics, and cyanoacrylics. Most new adhesives will probably be blends and alloys of existing polymers rather than totally new materials, predicts Fred Keimel, president of Adhesives and Sealants Consultants.

Epoxies stand to remain the workhorses. They are valued for their tensile and shear strengths, which can exceed 6000 pounds per square inch; fiber-reinforced formulations reach 10,000 psi. Their service temperatures range from −70° to 450° F; they readily fill gaps, and resist moisture, fuels, and many chemicals. Although epoxies are ordinarily highly insulating, they can be made almost as conductive as solder by mixing in finely divided metals.

Peel strength has always been a problem. Adesives peel along a separation line measured in inches. Standard epoxies fail under peeling forces as low as 4–6 pounds per inch. But the addition of liquid elastomers has raised the peel strength to as much as 35 pounds per inch when bonding aluminum, while retaining the tensile strength. Other new blends stand up to strong solvents such as butyl acetate, as well as to 98% sulphuric acid. Temperature resistance has been enhanced by the recent introduction of bismaleimide epoxies. These give service to 550° F and retain half their strength at that temperature for 1000 hours in continuous use. However, bismaleimide epoxies are at least twice as expensive as conventional versions.

Urethane-based adhesives can often compete with epoxies. They are good gap fillers, and frequently serve as sealants. While able to carry only about half the load of epoxies, they are generally much more resistant to vibration and shock. Urethanes cure in as little as five minutes, but GM and other automakers are demanding even faster curing. Essex Chemicals, a leading supplier, is seeking to develop formulations that cure more quickly under ultraviolet light.

Acrylics, another quick-setting class of adhesives, are poor gap fillers but resist impact and peeling. They are valued for their ability to bond oily metal surfaces. Bostik has a grade that can be premixed for ready use on a production line. And Lord, a leading auto-industry supplier, has an epoxy-acrylic blend that it hopes will be used to replace some welds.

Anaerobics and **cyanoacrylics** are more specialized than the other classes of structural adhesives. They set very quickly at room temperature, but require close mating of parts and very clean surfaces. Anaerobics cure in thin films on metal surfaces, in the absence of air; they thus serve to hold nuts on bolts. A drawback is that at $250 per gallon, anaerobics are far costlier than epoxies. Cyanoacrylics, familiar as Krazy Glue, react to trace amounts of moisture that allow them to polymerize and set in only a few seconds. They are quite potent; a single ounce can make some 2000 bonds. Previous versions have been runny, but Loctite has introduced a proprietary thickener that makes these adhesives suitable for porous surfaces.

And then there is the advice of one Bell Labs scientist: "If all else fails, use bloody great nails."

work best on surfaces that are more or less planar. The reason for such restricted use of adhesives lies in the sheer unwieldiness of the process. Adhesives must be applied manually; moreover, curing would require autoclaves larger than any that exist today. Even Boeing is not prepared to autoclave the wing of a 150-passenger airliner, let alone of a 747.

Adhesive bonding is thus finding its niche in the manufacture of small commuter aircraft, for which the needed autoclaves are relatively modest. Fokker (Schiphol, the Netherlands), with a long-standing commitment to this process, applies structural adhesives extensively in producing wing and fuselage panels for its F-27 and F-28. Its autoclave cures 400 square feet of bonded panels at a time—sufficient for a complete F-27 wing skin, but not nearly enough for even the flaps of a 747. Similarly, Fairchild Republic (Farmingdale, N.Y.) is using adhesive bonding in some of the wings being built for Saab's SF-340 passenger airliner.

A pickup truck suffered $2000 in damage from colliding with a glued-together golf cart; the cart was fixed in hours.

While their use in metal aircraft has been limited, adhesives will become essential to hold together new planes made from composites—fiberglass, Kevlar, or carbon fibers within an epoxy matrix. The weight-saving advantages of these materials have already brought such all-composite aircraft as the Starship business jet from Beech Aircraft, while Boeing is considering composite wings for its proposed 7J7 twin-engine airliner. If Boeing goes with composites, the company will install wing-size autoclaves for the airliner's production, on a scale it has never found justifiable for use with adhesive bonding. □

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BETTER DRUG PACKAGING THWARTS SABOTEURS

When intact, a multilayer plastic tape shimmers blue and green; opening the package it's affixed to disturbs the optical alignment of thin films, rendering the tape transparent. Cost per package is about 2¢. Individual capsules can be protected by a gelatin seal that rips conspicuously.

The aim of tamper-proofing is to discourage saboteurs of packaged food and pharmaceuticals. Unfortunately, experts agree that virtually all current tamper-resistant and tamper-evident techniques can be circumvented. Therefore, more advanced methods are being developed for sealing containers and for detecting violations of seals after they have occurred. Some of the most promising new developments include self-sealing capsules, bottle-making equipment that produces integral seals, and films that change characteristics when handled.

Research in better packaging reflects consumer and industry concern over the rise in tampering: in 1986 the Food and Drug Administration investigated 1526 reported cases, more than 10 times as many as in 1985. Although some tampering may be caused by disgruntled employees during processing, most occurs at the retail level. Tamperers typically buy or steal items, sabotage them—often by inconspicuously opening and resealing the packaging or injecting a foreign substance—and then sneak them back onto store shelves.

For businesses, the economic effects of tampering can be staggering. When several people died of poisoned Tylenol capsules in 1982, McNeil Laboratories (Fort Washington, Pa.) lost $150 million in recall and disposal costs alone. Even unconfirmed reports can hurt. A heavily publicized rumor of glass in baby food in 1986 caused an 11% market share drop for Gerber, which the company is still trying to regain.

"Industry is well aware of the liability aspect of this issue and is willing to spend the extra money to make packaging safer," says William Lampkin, chief of the Manufacturing Surveillance Branch of the Food and Drug Administration. For the past eight months the FDA has been working on a major upgrade of its original tamper-resistant requirements issued in November 1982. The additions are likely to include requirements for sealed capsules, better glues, and the substitution of metal cans for some less secure plastic containers.

Even before the new requirements are published, companies are unveiling even better means to deter saboteurs, especially in areas of particular concern like pharmaceutical capsules. Because of their vulnerability, some companies, including Johnson & Johnson, have eliminated capsulated medicines from their product lines altogether. Other producers, however, are beginning to use sealed capsules that cannot be opened without ripping. For example, Eli Lilly and Co. supplies Qualiseal equipment that produces gelatin capsules with thin bands of extra gelatin attached to the lips of the two halves. When the halves are joined, the bands overlap and meld to form a permanent seal. Similarly, Capsule Technology International has developed Etaseal capsules with crimps around the opening of each half. When joined, the two halves lock together, forming an hourglass-shaped capsule that cannot be pulled apart, the company claims.

In yet another approach, Procaps Machine is awaiting patents on a method that would produce single-piece, hard-shell gelatin capsules. And R. P. Scherer Hard-capsule offers Soniseal 2000, a machine that welds capsule joints using sonics to

by G. Berton Latamore

MIKE MALYSZKO

create rapid, heat-generating vibrations.

To protect liquid from sabotage, Automatic Liquid Packaging has introduced a machine that blow-molds, fills, and seals eyedropper bottles at a single station, isolating the product from possible tampering by workers. For protection at retail stores, the packaging equipment fabricates the dropper top and seals it to the filled container, leaving a rim of extra plastic flashing on the top. After applying a screw-on cap over the eyedropper top, the device then uses the flashing to form a clear plastic "bubble" extending around and over the threaded cap. Because this bubble seal is integral to the package, once removed it cannot be replaced.

For products that cannot be protected with an integral seal, a new class of thin, optically variable sealing films is available. They can be either adhesively bonded to packages or hot-stamped, a process using heat and pressure to firmly stamp the plastic film in place, perhaps to hold a cap on a bottle. The films are made of multiple layers of thin plastic membranes, configured to create specific optical effects.

During tampering, the precise alignment of the layers is irrevocably destroyed, making the material transparent. If punctured by a hypodermic needle, a transparent blotch appears instantly around the hole. To make tampering even more apparent to consumers, a signal like the word *opened* can be printed on the package under the film, visible only if the optical effect is destroyed.

One such film, Polaproof developed by Polaroid, consists of two layers: the top laminate is impregnated with tiny cylindrical lenses, and the bottom holds alternating colored lines. The entire material can be overprinted with a logo or other message and sealed with a protective layer of clear plastic. Depending on the position of the viewer and the incoming light, the lenses magnify and distort the lines so that the film's color changes at different angles. An absence of color variations indicates tampering. Polaroid has not yet announced plans to commercialize the product.

Another material, invented by Optical Coatings Laboratories, and developed by technology consulting firm PA Technology, consists of several plastic layers of precisely configured thicknesses that create an illusion of color by altering light reflection, much like an oil slick on water. As some light wavelengths are absorbed and others reflected, the film appears to be two colors in shifting combinations. The thickness of the individual layers is controlled by vacuum deposition, in which vaporized material is forced to condense over the preceding layer. PA expects the seal to appear on the market in 12 to 18 months.

The big advantages of optically variable films are their low cost and compatibility with current labeling equipment. Richard Arons, head of PA's Advanced Materials Group, estimates that the Optical Coating seal would add about 2¢ to the cost of a package. This might be unacceptable for some products, however. Aluminum screw-on caps on soft-drink bottles, for instance, cost only about 1¢ each. But many over-the-counter drugs are relatively high-profit products, making the 2¢ addition acceptable.

The issue of cost is closely tied to the probability of tampering. A tamper-resistant dispenser cap—developed by John A. McConnell (Pahoa, Hawaii) and Everett W. Williamson (Newark, Cal.) to dispense pills one at a time through an elaborate double-door mechanism that requires the user to twist the cap one way, invert it, then twist it the other way—was presented to major U.S. pharmaceutical companies without success because of its high cost. In Japan, however, where tampering of over-the-counter products is even more widespread, companies are looking at the device.

In the U.S., says Arons, industry is generally concentrating on more conventional approaches such as heat-shrinkable wrapping, caps with breakaway skirts, and thin foil seals. "We have yet to see the next generation of advanced technologies that would exploit the chemical effects of exposure to air, optical effects using holograms or optically variable devices, or new, more clever mechanical embodiments," he says. That doesn't mean research has stopped, however. At PA, for instance, Arons is involved in the development of several proprietary technologies for a major pharmaceutical firm. The company has even investigated the use of electronic alarms in bottle tops. Unfortunately, much information on new developments must remain secret so that it does not fall into the hands of potential saboteurs.

According to Arons, the main trend in tamper-resistant and tamper-evident packaging is the use of multiple barriers, such as the sealed Contac capsules that are placed in a sealed plastic blister package and sold in a sealed box. Despite such precautions, better measures are needed: "We have a lot of sophisticated equipment in our labs," says Arons, "but we don't need any of it to defeat present-day packaging." □

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THE NEW OHIO ENTREPRENEURS

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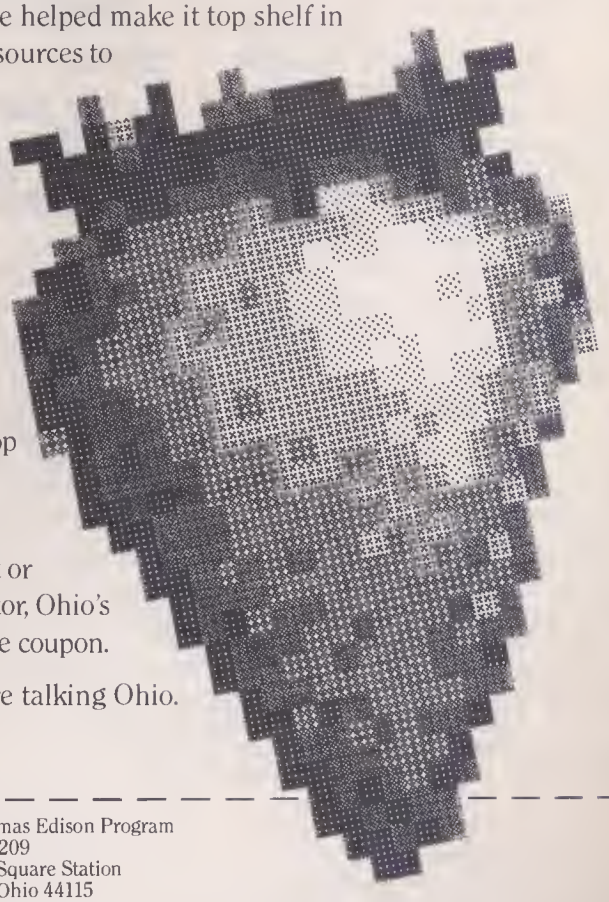

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FILLING IN WORD-PROCESSING GAPS

The main applications for microcomputers—word processing, spreadsheets, databases—are now well established, especially for the IBM PC and compatibles. The major software companies dominate the market for these applications, making competitive entry a difficult, expensive proposition. Rather than producing another word processor, a smaller company is better off developing a useful adjunct program that can work with an established product.

These adjunct programs perform a variety of chores that the main word-processing programs themselves do poorly if at all—ranging from file comparison to format conversion. Because each word-processing program stores information in its own file format, the adjunct programs in most cases must understand that particular format. This forces the designers of adjunct programs to pick which word processors to support. The designers naturally choose the market leaders, thus reinforcing the leaders' hold on the market.

One common problem with word-processed documents is keeping track of multiple changes, especially when several people have made revisions. Many programs have been written to compare files; MS-DOS even includes a simple compare utility (the COMP command) that reports whether or not two files are identical. Most such comparison programs were designed for programmers, and thus work with source code (the lines of instructions in a program). A programmer's comparison program treats individual lines as logical units, a valid approach for source code. But it does not deal with natural-language text, where sentences and phrases have variable lengths and break across lines.

CompareRite from JURISoft, by contrast, is an auxiliary program that compares full English text and marks passages that have been added or deleted. It has obvious value in comparing legal and other documents where fine details must be scrutinized, but it helps out in many other situations as well. For example, if you work on computers in your office and home, you probably carry a floppy disk containing your current work between the two machines. Occasionally you may find yourself working on the "wrong" file, resulting in two files with different revisions. CompareRite will quickly find and report the differences.

CompareRite can handle the native file formats of nine popular word processors as well as plain ASCII (unformatted) text; but note that for a comparison the two files must be of the same type.

Adjunct programs perform chores that the main word-processing programs do poorly if at all.

One aspect of document creation where paper has had an advantage over word processing is in marginal notes—comments that are not actually part of the text. But handwritten notes on paper do not copy well, and revising them usually creates a mess. Marginal notes by several reviewers written on separate copies produce at best a complicated revision job.

Broderbund Software's ForComment turns marginal notation into a streamlined electronic process. The original author prepares a document with a standard word processor, and then uses ForComment to set up a comment process for reviewers. Each reviewer adds comments to the document using a separate ForComment program, selecting specific lines and attaching notes. The display presents the original in the upper half of the screen, and a dot in the left margin indicates where a note has been attached. All notes appear in a separate window at the bottom of the screen. Reviewers can also propose revisions with a handy feature that switches between the original and the revision for quick comparison. Each note and revision is dated and "initialed" by the reviewer. After the reviewers have completed their notes, ForComment compiles them for the author and presents them in a window below the original document.

ForComment, which works directly with MultiMate, WordPerfect, WordStar, and plain ASCII files, is a complex stand-alone program; you cannot pop it up while running your word processor. This means that you must use ForComment's editor program to create and review comments rather than your own word processor. Although you won't be able to use familiar editing methods, you can configure the ForComment editor commands to mimic your word processor. In any event, notes are usually short, so editing should be minimal.

What can you do if one division of your company has standardized on word processor A but another division has chosen word processor B? You could create a plain ASCII file with program A and then read it with program B, but all the formatting information in the A file would be lost. You would have to recreate the formatting—the margins, page length, type style, and any other features of the original document. A format conversion program takes a file from one word-processing program and converts it into a file for another. The conversion should preserve as much formatting information as possible, but features in program A that are missing in program B cannot be converted, a restiction that will occasionally cause problems.

The emphasis until recently was on media conversion—converting disks created on one type of computer or dedicated word processor to another. Special hardware, disk controllers, and floppy disk drives have been developed to read and write a variety of formats. However, as more companies have switched to word processing in the IBM PC format, the demand for such hardware conversion products has waned. The need now is for purely software file conversion programs that can work with the MS-DOS files created by different IBM PC word processors.

To move from one format to another efficiently requires an intermediate format; each specific program then need only convert to and from the intermediate format rather than deal with every possible format. DCA/RFT (Document Content Architecture/Revisable-Form Text) is an intermediate file format defined by IBM for its word-processing programs. DCA includes

by Cary Lu

...ear Bush in his 1945 Atlantic Monthly article titled "... *May Think*". Bush's article inspired several greats of the computer industry – Ted Nelson, Douglas Englebart,

Hypertext lets readers see references instantly while reading a document. Here, with Owl International's Guide program, the window on the right explains the origin of the term, while the left window shows the text referred to in the main document.

COURTESY OWL INTERNATIONAL

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such functions as margins, page length, underscore, and so on. Word-processing programs create DCA files separately from their own native file format. When a user loads a DCA file, it is converted into the word processor's native file format so that it looks as if it was generated by that program.

This DCA capability is important enough that most business users should insist that their word processor include it. All major MS-DOS word processors now have DCA, although they do not always deal with every possible DCA function (few use DCA's outlining feature, for example). DCA itself hardly encompasses every desirable function; because it was designed for monospaced text with fixed-character widths, it does not handle fonts or graphics. On the IBM PC, this does not matter much, since none of the current major word processors deals effectively with fonts or graphics either. Despite these caveats, the DCA translation feature built into the major word processors are sufficient for most casual conversion tasks where occasional lapses can be corrected in the receiving word processor. Some page makeup programs, such as the MS-DOS PageMaker, can import DCA files. On Apple's Macintosh, only Microsoft Word directly supports DCA so far.

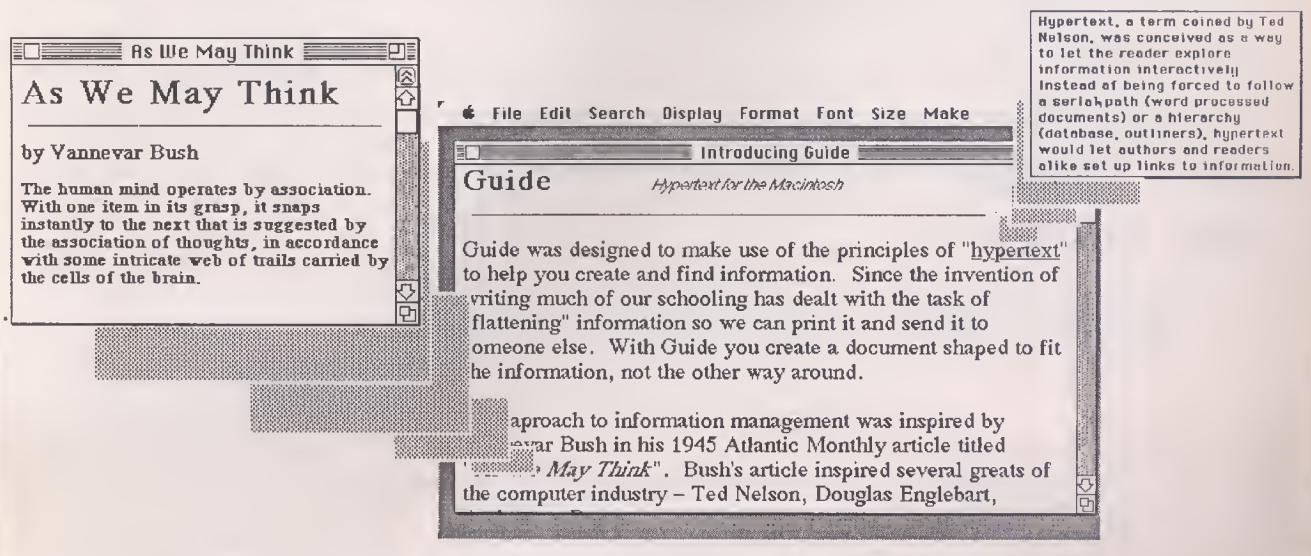
If you frequently need to convert complex documents between two or more word processor formats, or if you receive a lot of unformatted electronic mail, you should consider more flexible and robust conversion software than the simple DCA translators. Three stand-alone programs can transfer formatted files bidirectionally between any of a half-dozen or more word processors. All three have an ASCII file conversion feature that can take a plain ASCII file with carriage returns after every line (such as those sent through MCI Mail) and turn it into a word-processing document with defined paragraphs, multiple spaces converted into tabs, and centered text. All can deal with files from WordStar, MultiMate, and DisplayWrite 3 (via DCA), Microsoft Word (MS-DOS version), and WordPerfect; all convert directly without such intermediate steps as the need to create a DCA file (while these programs *do* go through an intermediate file of their own, the process does not involve the user). Each program can be run in a batch mode to convert multiple files or whole disks. And each renders unconvertible formatting codes as special characters in the receiving document so that they can be found quickly.

Mastersoft's Word for Word, the lowest-cost package ($149), adds support for OfficeWriter, Volkswriter, PFS:Write, and IBM Writing Assistant. It can also create a special file with formatting coded into plain ASCII that can be sent via any electronic mail service; a recipient with Word for Word can reconstitute the original file complete with formatting.

Software Bridge ($249) from Systems Compatibility Corp. adds support for the Wang PC word processor (but not Wang's dedicated word-processing or minicomputer products), Volkswriter, and Samna. Its ASCII conversion feature is user-definable, a valuable feature. For example, the program monitors line lengths to set page margins; you can alter its sensitivity to line-length changes to prevent a spurious margin change.

Principal Systems' PC Switch ($495) adds only Samna support and is a little expensive for its features.

At the high end, Keyword sells Softpak, a collection of programs that can convert among many different word processors. Each program costs $449 and converts bidirectionally between just two



COURTESY OWL INTERNATIONAL

Hypertext lets readers see references instantly while reading a document. Here, with Owl International's Guide program, the window on the right explains the origin of the term, while the left window shows the text referred to in the main document.

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formats. Although the conversion quality is high, only users with a large volume of files will find the price justified.

Ultimately, if the functions of an adjunct program prove popular, the mainstream word-processing programs will incorporate them. This is how spelling programs became included in every major word processor; thesauruses are also becoming popular as built-in features.

Similarly, Microsoft Word and WordPerfect have added outlining. Several programs provide for nonprinting notes within a document, although none offers the power and flexibility of ForComment. Lotus Manuscript includes a simple file comparison feature, and Samna has a revision marking function; other programs will begin adding comparison and revision features.

The next generation of word processors on the IBM PC will have to include strong graphics and font capabilities, to enhance desktop publishing and similar applications. Therefore, an enhanced DCA or a new intermediate file format will be necessary. Microsoft has begun using its own intermediate format with graphics and fonts, called RTF (Rich Text Format). Already available on the Macintosh version of Microsoft Word, RTF will begin appearing in Microsoft Windows applications later this year. RTF will come into its own if other software publishers planning graphics-rich programs adopt it.

Hypertext could become a key feature for the word processors of the 1990s. Based on a idea by Ted Nelson, hypertext links documents together according to references or common passages. While reading a document, you can display all passages that refer to an earlier document or are quoted in a later document. By pointing to the passage, you can instantly retrieve the complete referenced document.

For mundane business applications, Hypertext provides a comprehensive structure for revisions and comments, as well as a means of following concepts across multiple documents. A full-scale hypertext system requires considerable computing resources and disk capacity, plus a sophisticated authoring system. Nevertheless, the first commercial product with essential hypertext features, Owl International's Guide, is already available on the Macintosh and will be out on Microsoft Windows.

A second component of word processing for the 1990s will be adaptive software, which tracks your work habits and modifies itself accordingly. For instance, after you have created several memos in a specific layout, this software will automatically propose the same memo layout the next time you type MEMO at the top of a page. Through hypertext, you can retrieve standard paragraphs—say, for a legal document—merely by typing the first few words. If you change your memo format several times, the program will change the layout it proposes accordingly. The program will hardly do everything, but it will be able to mimic the more mechanical functions of a secretary.

In the 1990s, we will come to think of the word processors that we used in the 1980s as quaint products akin to manual typewriters. Remember them? □

Cary Lu is microcomputer editor of HIGH TECHNOLOGY.

ELECTRONICS IN CHINA: THE GREAT LEAP FORWARD

China's present government, determined to upgrade the country's outmoded infrastructure, modernize industry, and raise the nation's standard of living, recognizes that advanced technologies—and in many cases management techniques borrowed from other countries—are essential ingredients. And because electronics is basic to most modern industries, this area of technology is receiving high priority, says John Callebaut, director of development and government relations for the National Council for U.S.–China Trade, an industry-sponsored group in Washington, D.C.

By world standards, China's electronics industry still has a long way to go. In semiconductor production, for example, "there is a big gap in many areas," admits He Mingzhang, deputy director of R&D for National Electronic Devices, the arm of the Ministry of Electronics Industries (MEI) that coordinates electronics development and manufacturing. The chief obstacles to progress, he says, are the country's lagging capabilities in computer-aided design, engineering, and manufacturing, coupled with a lack of adequate equipment in certain key semiconductor production areas.

For example, while China has imported several complete semiconductor production lines, it does not have specialized chemical purification systems that would help reduce contamination in critical manufacturing steps. Also, the country is unable to make the sensitive monitoring equipment needed to maintain precise process control, says He. And because of the equipment's potential military use, China (along with other communist countries) is barred from importing it from the United States, Japan, and Europe by the Coordinating Committee for Multilateral Export Control (COCOM), a Paris-based organization of NATO countries.

Nevertheless, China currently produces an array of analog and digital integrated circuits for communications equipment, instrumentation, consumer products, and computers, including 64k RAM chips and 4- and 8-bit microprocessors, according to He. The country has also produced prototype gallium arsenide (GaAs) gate array chips, though still at a low to medium level of integration (fewer than 1000 devices per chip). All equipment used to fabricate the two-inch GaAs wafers from which the chips are made is domestically designed, adds He, since GaAs production equipment is another item on COCOM's off-limits list.

China uses its own equipment to produce small gate array chips. Here, a technician cuts a gallium arsenide crystal.

Current semiconductor research programs focus on microwave components for telecommunications applications and on high-level integrated circuits, according to He. The most ambitious project is a proposed $40 million plant to manufacture chips for automated telephone exchanges. To be located in Wuxi (a city near Shanghai that is becoming known as China's Silicon Valley), the plant will be a joint venture with foreign companies; potential partners include AT&T, West Germany's Siemens, and France's Thomson.

In addition to MEI's own activities, a series of sweeping economic reforms announced by the government last fall will have a profound effect on the electronics industry, says Zhang Zhidong, vice-president of the ministry's import-export arm. These reforms will loosen the ministry's grip of China's central planning agencies, which until now have kept tight control over every aspect of production. "The principles of the free market did not apply," says Zhang. "As a result, productivity was low and there was no efficiency." And ironically, centralized authority made cooperation among factories virtually impossible. "One factory under MEI couldn't talk to another factory because each reported to a higher authority through different channels," explains Zhang. As the reforms are enacted, planning functions will shift to municipal governments and individual factories, thus "giving factories and other enterprises more decisionmaking power, including the power to initiate things," says Zhang.

It will even be possible for them to forge their own alliances. One example is the Panda Group in Nanjing province, which consists of several factories making color TVs and tape recorders. "One factory used to report to the Bureau of Administration and Broadcasting, another to the Administration of Components. In the past, it was unimaginable that the two factories could get together and talk about common problems," says Zhang. But now, "they are able to start cooperating." Another new alliance combines Great Wall Microcomputer, Longxin Electronics, Kunlun Electronic Printing, North Computer Auxiliary Design, and China Computer Leasing into the China Computer Development Corp., which will coordinate imports of computers and technology as well as oversee domestic manufacturing.

Interestingly enough, the author of these economic reforms is none other than Zhao Ziyang, the new secretary of the Chinese Communist Party's Central Committee, who recently replaced ousted secretary Hu. Zhao's commitment to such reforms bodes well for China's continued economic alliances with other countries and its increased openness to foreign ideas—despite tensions caused by this past winter's student protests. "We will continue the policy of opening to the outside world," said Zhao in a statement reported in late January by Xinhua, China's official news agency. "We will expand instead of reduce our cooperation with foreign countries." □ ***—Sarah Glazer***

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by Robert Cullen

Discount firms with on-line services include Fidelity Brokerage Service, Charles Schwab, and Spear Securities. These firms also maintain investment portfolios for on-line traders, automatically routing confirmations of buy and sell orders to investors' accounts.

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These three firms provide only raw data, leaving it to the investor to know what to look for—such as information on price/earnings ratios and annual percent increases in earnings per share—and how to evaluate it. The investor who doesn't have the time or inclination to carry out a fundamental analysis can consult Value Screen/Plus, an electronic version of the popular investment advisory service published by Value Line. Value Screen/Plus provides data, including stock ratings, on companies traded on the New York Stock Exchange.

Technically minded investors can use two programs published by Computer Asset Management: MetaStock (historical price and volume trading data on individual stocks), and The Technician (historical trading information on major market indexes and macroeconomic indicators, such as the money supply). Both programs access databases maintained by the vendor, graph the data, and manipulate it according to the investor's criteria. For example, MetaStock can show how the price of a stock has reacted on a 30-day moving average, one indicator of trading patterns that could be used to project future performance. □

Robert Cullen is a financial journalist based in Pasadena, Cal., specializing in computer applications for private investors and financial professionals.

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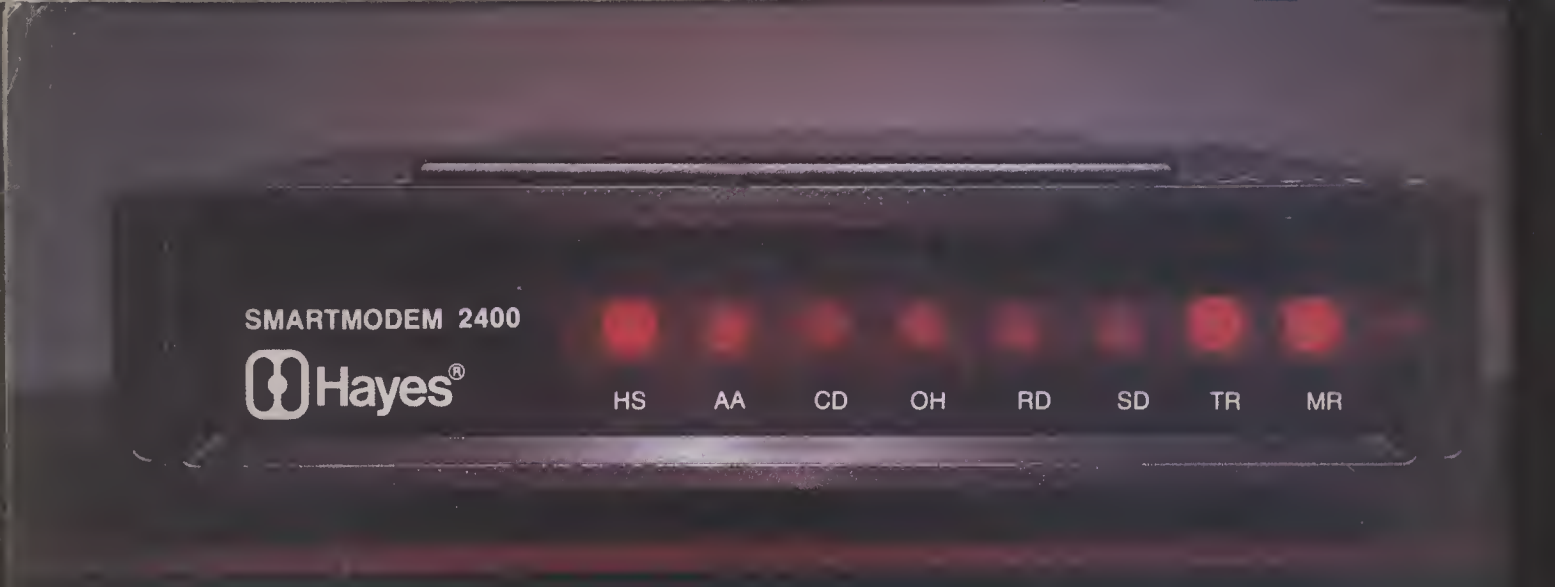

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